World Ocean Circulation Experiment

NEWSLETTER

Number 14 June 1993

FEATURES

RECENT WOCE HIGHLIGHTS

The Field Programme

During the past 9 months observational work for WOCE was carried out in all oceans. In the South Atlantic the intensive observational programme of the Deep Basin Experiment (DBE) has been successful, with a number of hydrographic sections completed, and moorings, drifters and floats deployed. It is clear from the Experiment that the Hunter Channel plays an essential role, in addition to the Vema Channel, for the Bottom Water flow from the Argentine to the Brazil Basin. A good data set has now been obtained in the South Atlantic for the shallow and the deep western boundary current regime. In particular, a total of 11 moorings were recovered successfully after about 2 years, spanning the western boundary current

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regime between the Vema Channel and the Brazilian coast (arrays ACM3 and ACM12). Six new current meter moorings were deployed in the Hunter Channel, another one in the outflow extension on the eastern flank of the Rio Grande Rise, and one in the northward extension of the Vema Channel (see the feature on the DBE, page 4). The USA/WHOI deployed 36 RAFOS floats in accordance with CP1 and CP3 requirements in the South and Tropical Atlantic, while the Germans launched 17 floats of the same type in the northwestern South Atlantic.

In the same ocean basin the one-time hydrographic sections A10 and A11 along 35°S and 45°S were completed by Germany and the UK, respectively (see features on A10 on page 2 and A11 on page 8). In the tropical Atlantic the WHP sections A6 and A7 were occupied by France in early 1993. During the Subduction Experiment the USA launched 6 ALACE floats in the southeastern North Atlantic (AR11, Control Volume II).

In the Southern Ocean work included WHP repeat sections across the Drake Passage (UK, SR2), across the Weddell Sea (Germany), and a section between Tasmania and Antarctica (Australia, PR12). Also completed were the South Pacific one-time surveys of P19S (54°S to the ice edge), P16A (35°S to ice edge), P17E and P17A (33°S to 53°S). The USA deployed the remainder of a total of 42 ALACE floats released in the Southern Ocean during 1991 and 1992.

On many one-time WHP cruises JGOFS working groups are collaborating with WOCE scientists. The cooperative experience was reportedly especially successful between a Brookhaven JGOFS group (measuring CO_2 and other tracers) and the German IFM/Kiel WOCE group during the South Atlantic cruises last winter.

Throughout all the ocean basins around 1300 surface drifters were deployed. The coverage provided by these buoys in relation to the required coverage according to the WOCE Implementation Plan is being discussed by the Core Project Working Groups at their meetings this summer, and will be reviewed by the SVP PC later this fall.

New mooring arrays were deployed in the South Indian Ocean (SCM6 and SCM9; see the newsflash on UK WOCE on page 11), in the Western Pacific (PCM5; see the feature on the Kuroshio on page 22), and ACM10, ACM11, ACM13 and SCM2 were all deployed for the first time in late 1992 or early 1993.

The Scientific and Operational Committees

The accomplishments so far stand as examples of what can be achieved during the rest of the WOCE. Plans for completing some aspects of the field programme (*e.g.* the Western Pacific and the North Atlantic) were discussed amongst other things by the SSG at the WOCE-19 meeting in January 1993 in Southampton, UK (WOCE Report No. 103/93), and by the US SSC at their meeting in February in Dallas (Indian Ocean).

A major focus of the SSG meeting was the delay in the data evaluation process in all groups. The principal cause appears to be the extremely busy field work schedule of observational groups which leaves little time between cruises to calibrate and prepare the data for submission to the respective DAC. More clarity in the data flow from its origin to final archive is being provided by a Data Management Handbook, an interim version of which has just been published as WOCE Report No. 104/93. The start-up difficulties that the WHP Special Analysis Centre was struggling with have been overcome to some extent by the acquisition of a HP 9000/735 workstation with peripheral equipment, database management software compatible with that recently installed at the WHP Office, and various software tools useful for the homogenization of multiple data sets. One additional hydrographer with several years' experience in merging historical and recent data sets from the Southern Ocean was hired as SAC staff.

In April the fourth meeting of the Upper Ocean Thermal Data Assembly Data Centres took place in Hobart, during which real-time and delayed mode data quality control procedures were coordinated between the Pacific, Atlantic and Indian Ocean Regional Centres.

A10 FINISHED SUCCESSFULLY

The German research vessel Meteor has successfully conducted the WHP section A10 along 30°S from Rio de Janeiro to Cape Town. The observations relevant for WOCE and JGOFS were done by the Marine Physics and Chemistry groups of the Institut für Meereskunde (Kiel) and the Tracer Oceanography group of the University of Bremen. Chief Scientist was Reiner Onken (Kiel).

Meteor left Rio de Janeiro on 27 December 1992 at 18:00 for leg 5 of her 22nd cruise. The first destination was a test station located at waypoint A (see Figure 1). Because Meteor crossed the Brazil Current on her way to the test station, the temperature and velocity structure of this current were recorded with XBT drops and the shipborne ADCP (S-ADCP). On the test station, all instruments were tested and the

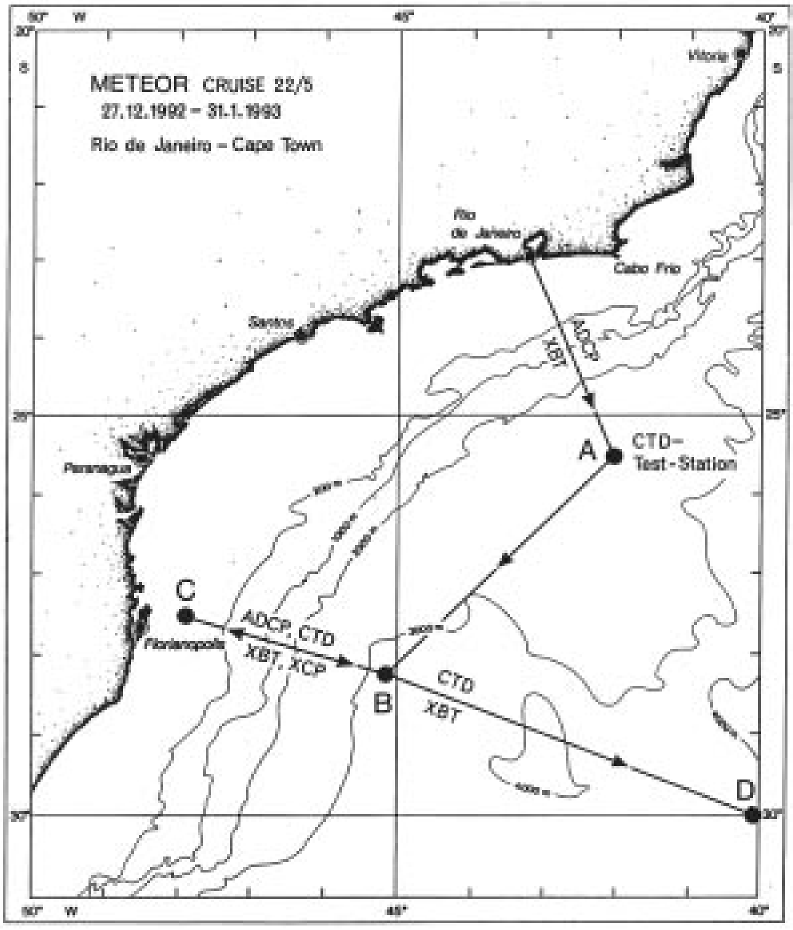

Figure 1. Cruise track (western part).

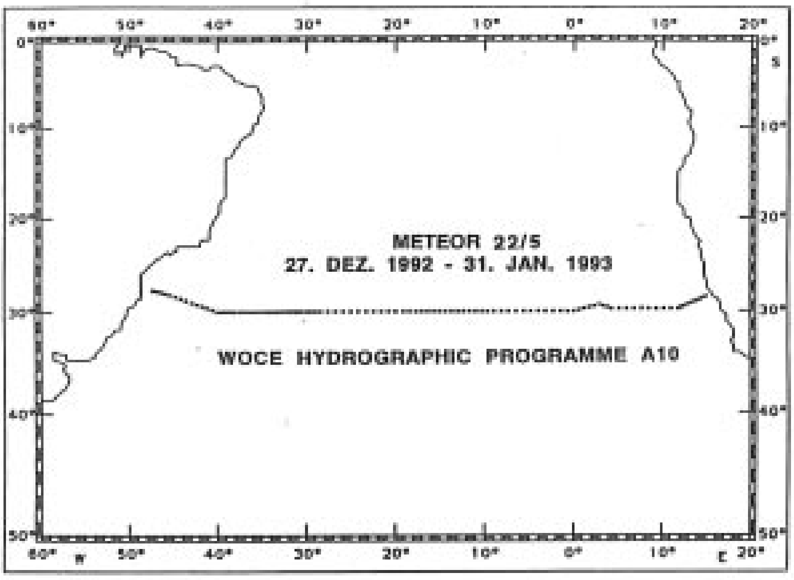

Figure 2. Stations along WHP section A10.

scientists familiarized themselves with their usage. As the overside ADCP (F-ADCP) was not yet ready for use, another test station was occupied in the early evening. Here, the F-ADCP passed its first test successfully. Afterwards Meteor headed for waypoint B. Between B and C the Brazil Current was crossed a second time and was surveyed again with XBT and S-ADCP. Meteor turned at C and hydrographic stations were occupied at 10 mile intervals between B and C. To the east of B, the interval between the stations was increased to 30 miles. The 30°S latitude was reached at waypoint D. For the following weeks, Meteor sailed along this line eastward (Figure 2). A northward detour was done over the Walvis Ridge because of the complicated topography. The intervals between stations varied between 9 and 45 miles. At 11°50’E the 30°S latitude was left and the station programme was continued in an east-northeast crossing of the Benguela Current. Here the station interval was reduced to 20 miles. The last station was located on the African shelf at a water depth of about 200 m. The measurements were finished in the afternoon of 28 January, and Meteor called at the port of Cape Town on 30 January 1993.

A summary of all observations is given by the following statistics:

Stations	113
CTD/Rosette profiles	186
F-ADCP profiles	15
10-l casts	3394
Salinity samples	1166
Oxygen and nutrient samples	2868
Total carbonate samples	1400
Chlorophyll samples	100
Alkalinity and pH samples	837
Tracer samples	
(Freon, Tritium, Helium, C_{14}, CCl_4)	3267
XBT launches	132
XCP launches	14
RAFOS float launches	1
Surface drifter launches	6

In addition, underway measurements of currents, temperature and salinity were done by S-ADCP and thermosalinograph and the CO_2 partial pressure difference was continuously recorded.

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METEOR FINISHES HER SECOND DBE CRUISE

Background

Within WOCE, the Deep Basin Experiment (DBE) aims to observe and model the deep water exchange between two ocean basins. The sparely investigated Brazil Basin was chosen for this study. The observational part of the DBE reqires year-long measurements with moored current meters at the basin's deep connections in the north and south as well as Langrangian measurements with neutrally buoyant floats at mid depths of the basin. The current measurements at the basin's southern margin and the RAFOS float project are coordinated efforts of the Institut für Meereskunde in Kiel, IfMK, and the Woods Hole Oceanographic Institution, WHOI. An intensification of the Lagrangian component is planned by IFREMER, Brest, in 1993.

During her first DBE cruise (M15/1-2) in January and February 1991, FS Meteor had launched 13 current meter moorings along the western part of the southern boundary of the Brazil Basin (Fig. 1) from the shelf break across the Santos Plateau towards the Vema Channel (Siedler and Zenk, 1992). The section of moorings combines WOCE arrays ACM3 on the western part of the heat flux section A10 and the DBE array ACM12 in the Vema Channel (WMO, 1988). A bathymetric survey of the Vema sill with the ship's multibeam echosounding system HYDROSWEEP (Zenk *et al.*, 1993) supported the selection of mooring sites in the channel and will help in the interpretation of the interaction between the observed currents and the bottom topography.

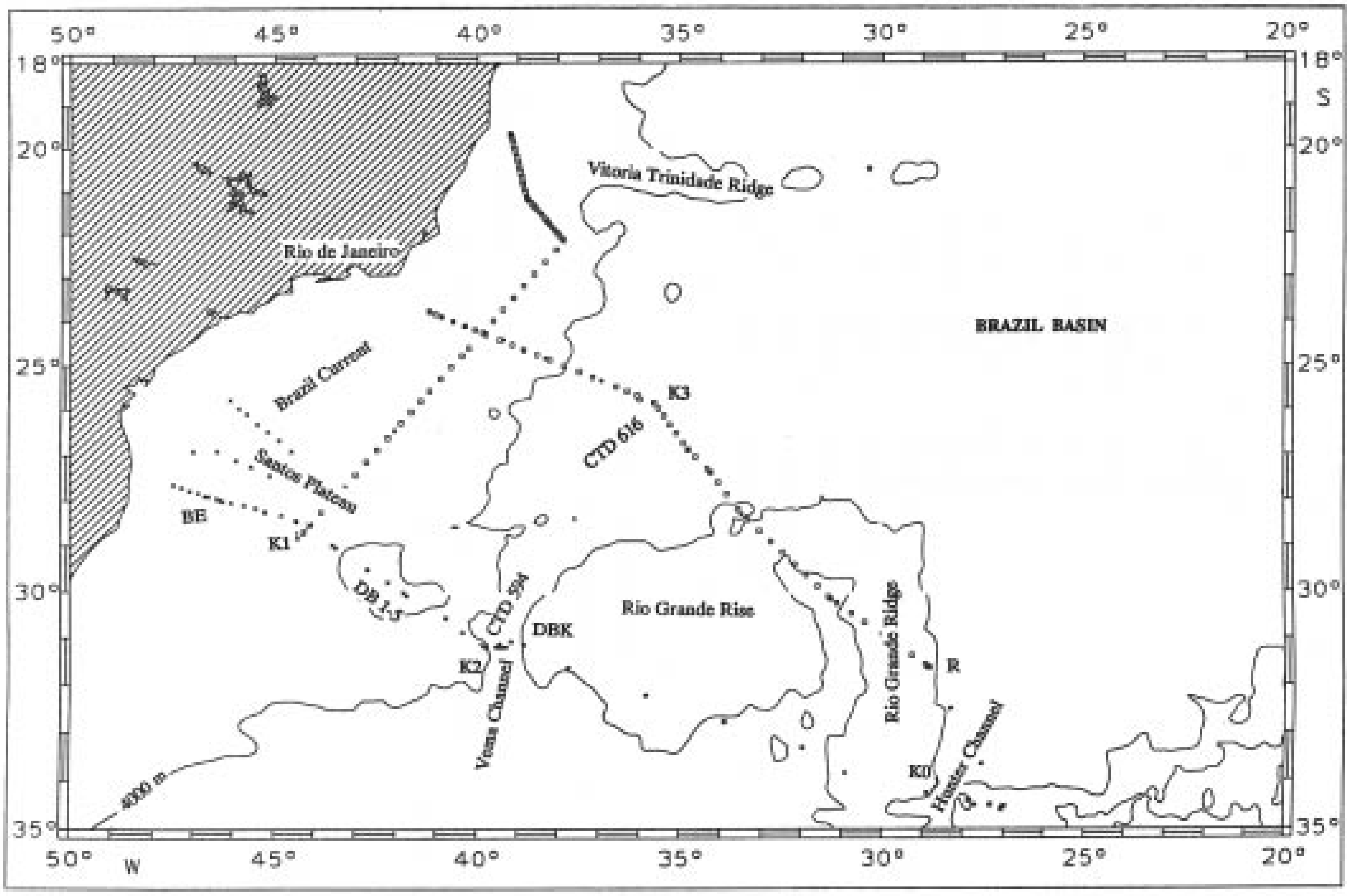

Figure 1: Track of Meteor cruise 22/3-4, 18 November to 22 December 1992 from Recife via Santos to Rio de Janeiro. CTD stations (crosses) and XBT drops (circles) are indicated. Eleven current meter moorings from arrays ACM3 and ACM12 and in between have been recovered after 23 months of deployement. Six current meter moorings were deployed in array ACM13 in the Hunter Channel, and one (R) in the Hunter Channel's outflow extension. Four moorings with sound sources at 900 m depth (K0 to K3) were deployed for RAFOS float tracking, K3 with additonal near bottom current meters to measure the flow of bottom water in a deep valley of the Vema Channel extension, called Vema Canyon.

The bathymetry of the Hunter Channel at the eastern part of the southern boundary was not yet well known in detail. Actually, many detailed features in available bottom charts appeared to be wrong. Deep CTD stations during that first DBE cruise however showed that a significant part of bottom water must flow northwards through the Hunter Channel (Speer *et al.*, 1992; Speer and Zenk, 1993), and a bathymetric survey, although incomplete, served to identify passages in the channel for placement of current meter moorings of array ACM13 (WMO, 1988) during the next cruise.

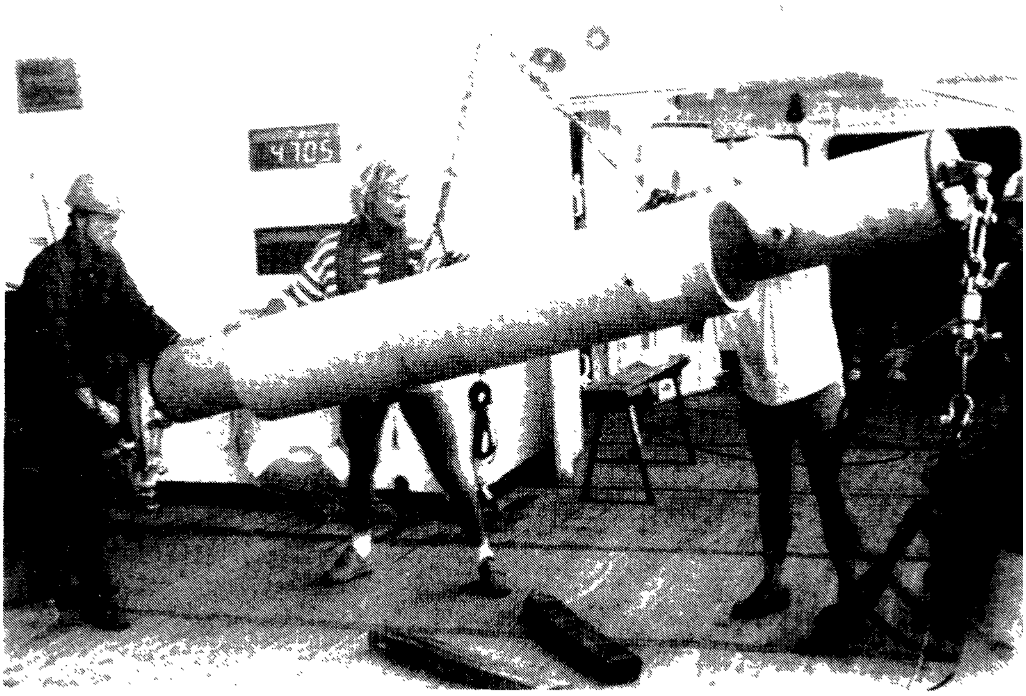

Figure 2: Deploying a sound source from Meteor.

Thus, the second DBE cruise of Meteor had three main objectives: to recover all current meter moorings from array ACM3/ACM12 after 23 months deployment, and to deploy six new current meter moorings in the Hunter Channel array ACM13 and one in the outflow extension on the eastern flank of the Rio Grande Rise. In addition, the acoustic array for the RAFOS float experiment within the Antarctic Intermediate Water, AAIW, had to be installed. Further, CTD sections across the Brazil Current and along the mooring sections and selected XBT drops were planned.

Narrative

Meteor cruise M22/3-4 consisted of two legs. Leg M22/3 began in Recife 18 November 1992 with 33 crew members, the Brazilian observer Cap.-Ten. J. Ramos, Jr., and 10 scientists and technicians from IfMK onboard. Heading south towards mooring position BE/335, some hydrographic measurements within the Brazil Current were made south of the Vitoria Trinidade Ridge and two test floats were placed at the 850 m depth level within the AAIW (Fig. 1). On 25 November we reached a position close to BE where the first (K1) of four IfMK moorings carrying sound sources was launched for the float experiment (Fig. 2). During the following two days, IfMK current meter moorings BE, BM and BW from ACM3 were recovered completely after 23 months. With three CTD sections across the Brazil Current, 120 km apart, leg M22/3 finished. For a short interruption of the cruise, Meteor called into port in Santos 30 November, where Walter Zenk took over as chief scientist from Thomas Müller.

Leg M22/4 started from Santos 2 December. Six scientists from the University of Sao Paulo, Rio de Janeiro and Woods Hole had joined the scientific party from IfMK. Initially, four WHOI moorings (DB1-4) linking ACM3 and ACM12 were recovered after 23 months without problems. To our surprise, the acoustic release of DB5 responded but failed to release. After numerous trials we started preparations to drag for DB5. However, we had to disrupt this effort because the weather became worse. Facing the substantial mooring work ahead of us, we had to give up this mooring on the eastern side of the Santos Plateau, and proceeded to the Vema Channel. On 2 December the second IfMK sound source mooring (K2) was deployed on the western Vema terrace. Next, IfMK moorings VW from the western shoulder and VE from the Vema sill were recovered, but VM was lost. Neither was it possible to communicate with the acoustic release of VM nor did it come into sight after several release commands had been sent. Moorings DBK and DB6 again were recovered without problems, and thus the mooring work within the line ACM3/ACM12 was completed.

We reached the Hunter Channel on 11 December. Due to bad wheather conditions with a gale blowing up to 12 Beaufort, launching of the 6 current meter moorings H1-6 of array ACM13 and the sound source mooring K0 was sometimes distressing. Again, due to unfavourable weather conditions we were unable to add significant information to the Hunter

Channel bathymetry with HYDROSWEEP. By 15 December we left the Hunter Channel region for a site on the eastern flank of the Rio Grande Ridge where a near-bottom mooring (R) was launched. During the first DBE cruise in 1991, Meteor had discovered a deep western boundary current on the eastern flank which will be monitored by the current meters of R.

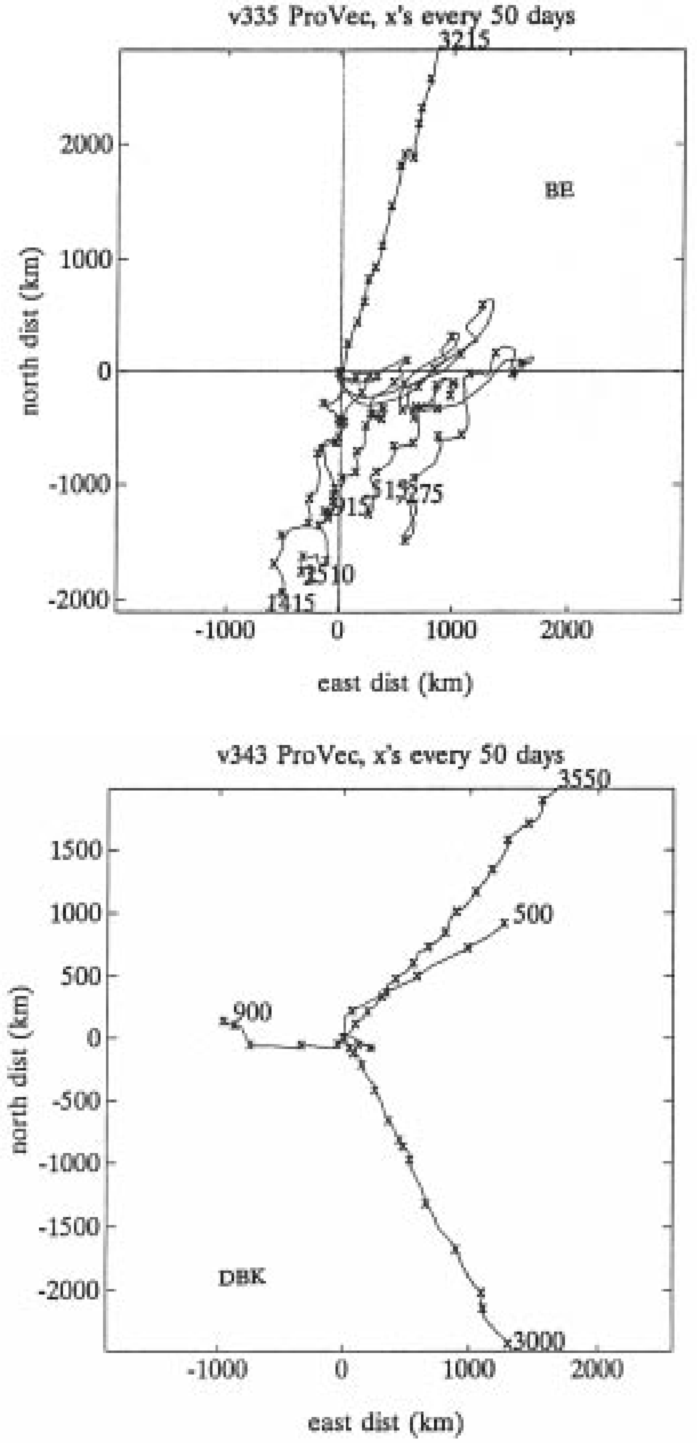

Figure 3: Progressive vector diagrams from (a) the deepest mooring of the heat flux arry ACM3 (BE/335) and (b) Vema Channel mooring DBK/343 in ACM12. All curves start at the origin, crosses indicate 50 day intervals, numbers depths.

The final mooring K3 with two near-bottom current meters and the fourth sound source was set into a channel which we believe to be a northward extension of the Vema Channel. Meteor called into port in Rio de Janeiro 22 December 1992.

Summarizing, 11 of 13 current meter moorings from the ACM3/ACM12 array were successfully recovered after 23 months deployment. As some consolation with respect to the two lost moorings, we note that there is still some hope that DB5 can be dragged successfully later because we know its exact position, and that VM was a short mooring mainly deployed for redundance with the recovered, more heavily equipped VE. Six current meter moorings were deployed in the Hunter Channel, two moorings with near bottom current meters into the extensions of the Hunter Channel and Vema Channel outflows, and an acoustic array with four sound sources for the RAFOS float experiment in the AAIW level was set up. In addition 20 RAFOS floats and 16 satellite tracked drifting buoys drogued at 100 m were launched.

Some Preliminary Results

Some of the current meter data could already be read and decoded from data storage units onboard. In figure 3(a) we show progressive vector diagrams of mooring BE on the offshore edge of the expected position of the Brazil current at about 3300 m water depth. Early in the record, an energetic event displaced all but the deepest trajectory eastward, while after passage of that feature these currents were steady towards the southwest, *i.e.* parallel to the local bathymetry. Contrarily, the whole record from the near-bottom current meter at 3215 m depth, shows north-easterly direction. The mean temperature recorded by this instrument is 1.7°C which indicates the upper level of Antarctic Bottom Water AABW entering the Brazil Basin from the southwest.

Figure 3(b) originates from mooring DBK on the eastern terrace of the Vema Channel and shows interesting contrast to the above vector diagram. Here, at three of the four stacked depth and water mass levels the flow sets into different directions. The deepest layer (3550 m, AABW) flows through the channel northeastwards into the Brazil Basin, the next one up (3000 m, NADW) southward into the Argentine Basin, the AAIW at 900 m (300 d record only) westward and the SACW at 500 m (250 d record only) again has a northeasterly component. More distinct directions of water mass flows could scarcely be found!

The transect back to Rio allowed an investigation of the northward route of Weddell Sea Deep Water, the coldest water crossing the Vema sill for greater depths of the Brazil Basin. The route of this bottom flow is by no means clear from existing charts. Having discovered a deep trough north of the Vema

Channel during the first DBE cruise, Meteor occupied a CTD station within this valley before deploying mooring K3 there. Potential temperature profiles (Fig. 4) show that the coldest water is just 26 mK warmer than the coldest water at the sill (-0.131°C compared to -0.157°C; the profile of Vema Canyon Station 616 is offset from that of Station 594 by $\Delta T = 0.6°C$). This exciting observation suggests that there must be direct deep connection between the sill and its extension at K3 which is hardly affected by any mixing. We suggest calling this hypothetical connecting trough the Vema Canyon.

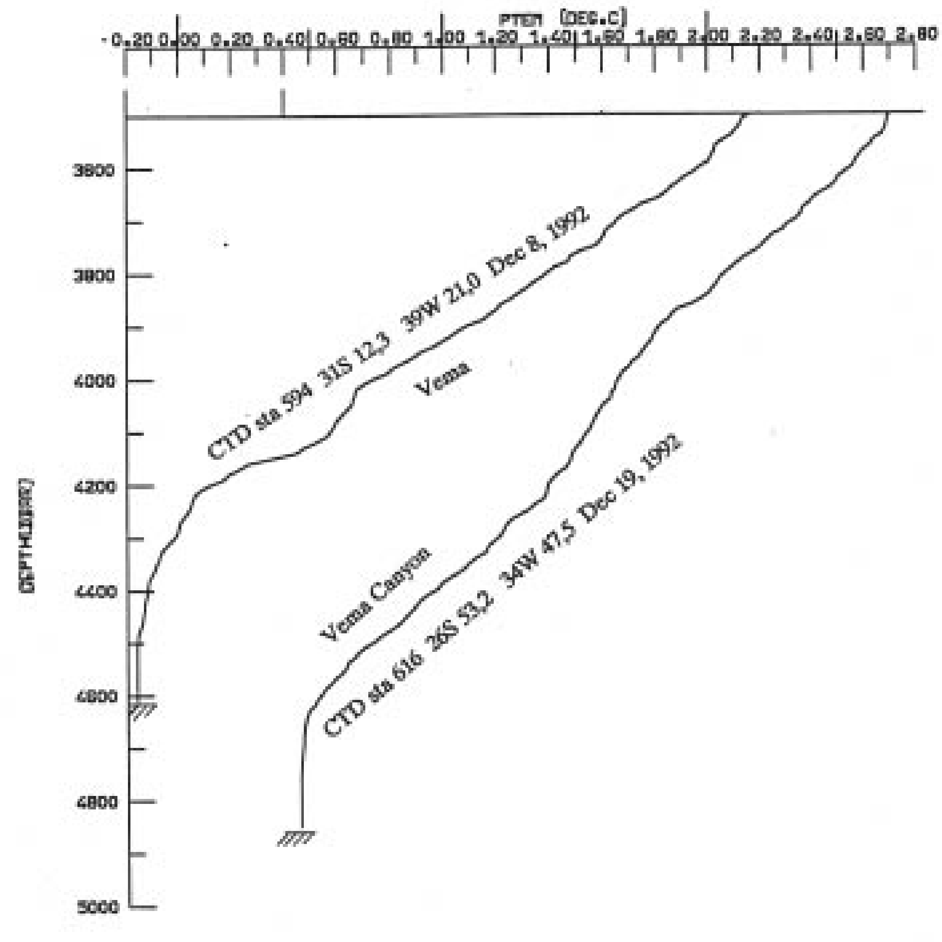

Figure 4: Vertical profiles of potential temperature at the Vema sill and the extension of the Vema Channel (Vema Canyon) at position K3 (cf fig. 1).

Acknowledgements

It was a great pleasure to cooperate jointly with colleagues from three countries - Germany, USA and Brazil - who all share interest in the physics of the South Atlantic. We gratefully acknowledge the excellent work of the mooring groups of IFMK and WHOI and the professional assistance that we experienced from Kapitän G. Müller and his crew. Special thanks go to Boatswain H. Jannsen and his sailors for the brave manoeuvre which they performed in a Zodiac when our mooring H6 dared to get lost during deployment in a severe rising storm.

Financial support was provided by the Deutsche Forschungsgemein-schaft, Bonn, under Si 111/39-1 and Ze/6-1, the Bundesminister für Forschung und Technologie, Bonn, under 03F0050D, and the National Science Foundation, Washington.

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Funding for the WOCE "Fast Delivery" Sea Level DAC

The "fast delivery" Sea Level Data Assembly Centre at the University of Hawaii has now been awarded funding. The Centre will receive sea level data from WOCE gauges required for validation of satellite altimeter data and distribute them 1-3 months after data collection.

A11 - DISCOVERY CRUISE 199

RRS Discovery sailed from Punta Arenas in the Strait of Magellan at the southern tip of Chile on 22 December 1992 and arrived in Capetown, South Africa on 1 February 1993.

In between it carried out the WOCE A11 section consisting of 91 hydrographic full-depth stations. It was one of about 80 similar cruises, some accomplished, some still in the planning stage, which will investigate and define the physical and chemical state of the global ocean in the period 1990-1997. The cruise track and station positions are shown in Figure 1.

The scientific objectives of the cruise were threefold:

(1) To estimate the oceanic exchange of heat, freshwater, nutrients and freons across the section, *i.e.* between the Southern Ocean and the South Atlantic,

(2) To determine the water mass characteristics of the section and to determine whether and where secular changes have occurred, and

(3) To submit, in a timely manner, the cruise data set to the WOCE data centre for assessment of its quality and therefore its fitness to be included in the CP1 global data set.

Principal Investigators for A11

Name	Responsibility	Affiliation
B. King	CTD	IOSDL
S. Bacon	Salinity	JRC
D. Hydes	Nutrients	IOSDL
P. Chapman	Oxygen	Texas A&M
D. Smythe-Wright	CFCs	JRC
P. Saunders	ADCP	IOSDL

Scientific personnel were enlisted from IOS Deacon Laboratory, the James Rennell Centre for Ocean Circulation, NERC Research Vessel Services, the University of East Anglia and Texas A&M University in the USA.

Hydrographic observations were made with a NBIS CTD equipped with an oxygen sensor, 1 m path transmissometer, altimeter and a GO Rosette. Up to 24 water samples, each of volume 10 litres, were drawn on each cast and the measurements that were made can be ascertained from the accompanying table. Unfortunately neither C_{14} nor Helium/Tritium measurements were made.

Figure 2 shows the distribution of sample observations made on the A11 section. Since data from the South Atlantic Ventilation Experiment (SAVE) were

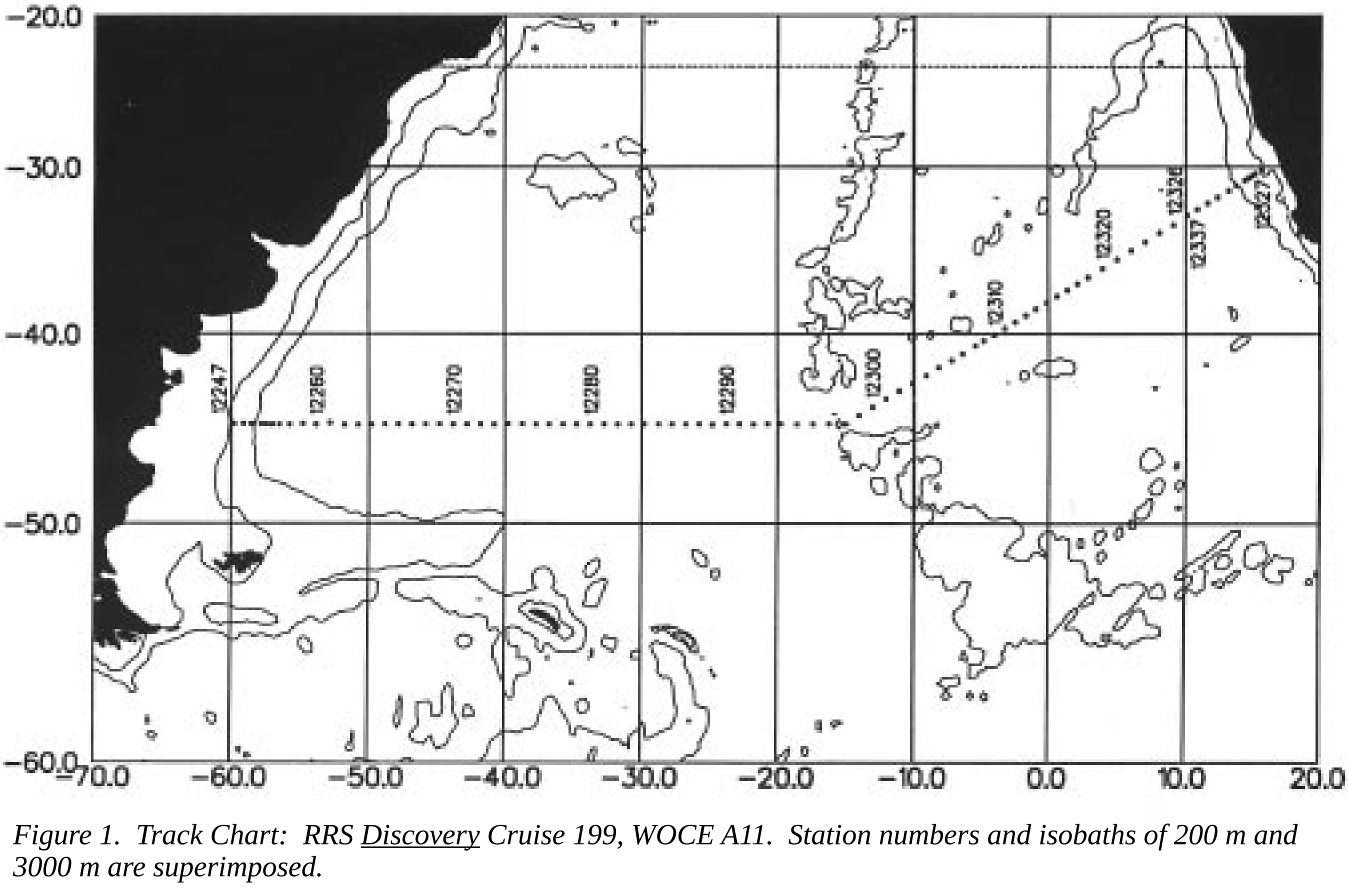

Figure 1. Track Chart: RRS Discovery Cruise 199, WOCE A11. Station numbers and isobaths of 200 m and 3000 m are superimposed.

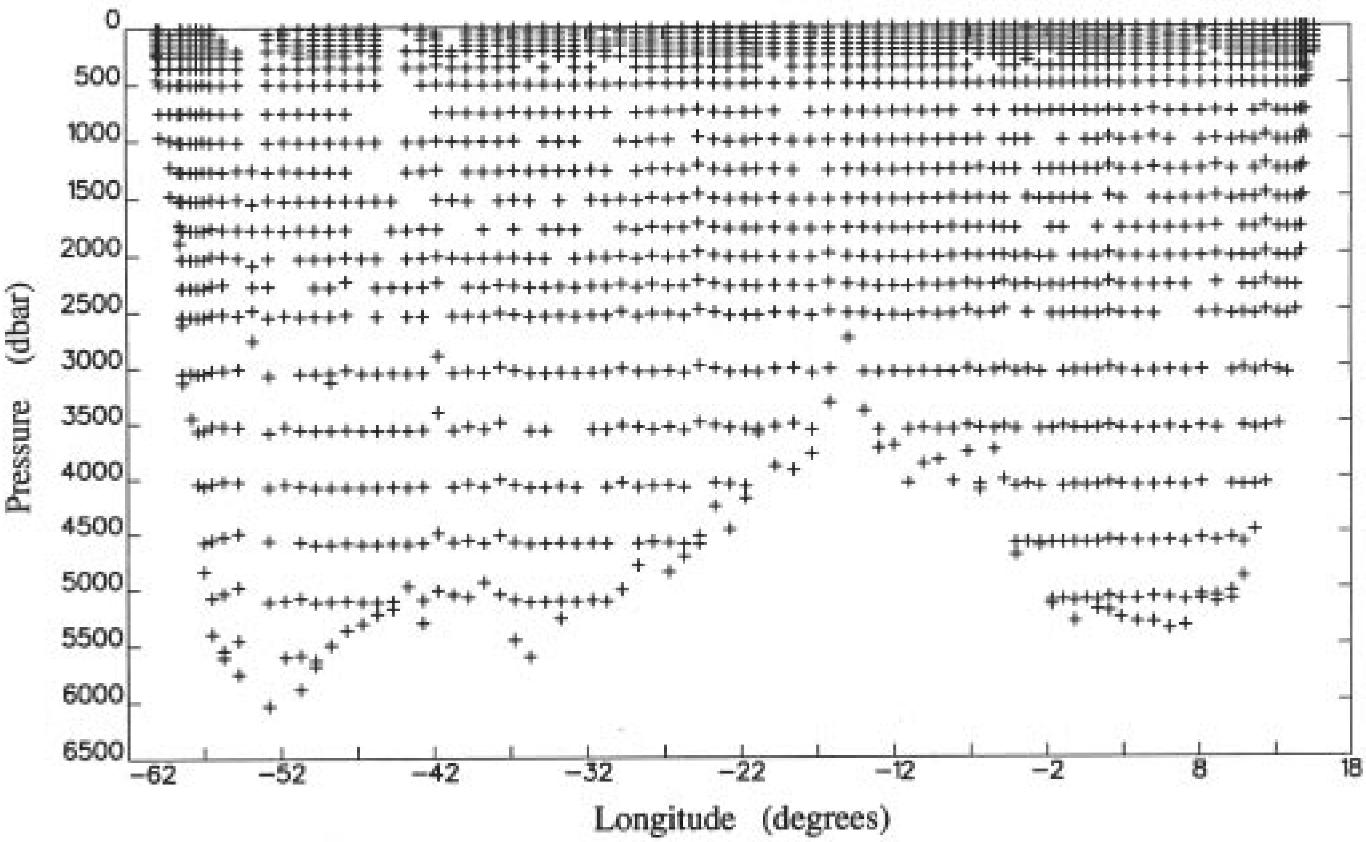

Figure 2. The location of 10 litre water samples collected on cruise A11.

available on the ship (thanks to WHPO), we were able to compare A11 and SAVE* sample data. The property distributions were very similar, but small differences were noted in the deep water which became evident with potential temperature <1.0˚C or salinity in the range 34.66 - 34.72. A11 salinity measurements agreed well with the SAVE 5 leg data, but were more saline by 0.002 than adjacent SAVE 4 data: the differences amongst the SAVE data were not previously known to us. Nitrates showed agreement with both SAVE 4 and 5 measurements, but at the deepest levels silicates and oxygens were both slightly lower by 2.5 umol/kg; phosphates were lower by about 0.08 umol/kg. These preliminary results apply principally within the Argentine Basin, and possible causes of the differences are under investigation.

A more unexpected result, which owed nothing to the accuracy of the measurements, was the extreme northern position of the Subtropical Convergence on the NE leg of the track (Figure 1). Although the water became progressively warmer along this leg, the surface salinity remained below 35 until a ring was encountered centred on 36° 20'S and 4° 00'E. The ring had a thermostad of temperature 13.5°C, salinity 35.2 and a maximum depth of 600 m. An anticyclonic circulation of 30 cms^{-1} was observed by the ADCP. It may have been an Agulhas ring which had over-wintered south of the convergence, or a Brazil Current ring shed in the WBC retroflexion zone which had migrated eastward. Opinions in the scientific party were split about equally, but a closer post-cruise examination of the data may well resolve the question. Beyond the ring's NE edge, near 35° 40'S and 5° 00'E we encountered the subtropical gyre, with a surface salinity exceeding 36 and temperature of 20°C. This observation appears to confirm Deacon's ancient assertion of the northward migration of the convergence in summer in this region. Some of these features are apparent on the thermosalinograph record shown in Figure 3.

A recently acquired GPS receiver, an Ashtech GPS3DF, was available on the cruise and our investigations show it is capable of determining heading to better than 0.1°, almost an order of magnitude improvement on the ship's Gyrocompass. This in turn produces a considerable improvement in the accuracy with which currents can be determined from the Acoustic Doppler Current Profiler (ADCP). On the Argentine Slope, on two crossings of the Falklands Current, large and persistent northward velocities were found at 100 m depth (30 - 50 cms^{-1}). These were considerably in excess of those predicted by the geostrophic shear (relative to the bottom), and consequently bottom velocities of 15 - 30 cms^{-1} are

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* SAVE 4: December 1988 - January 1989, cruise track similar to A11, starting at about 47°S in the west, ending at about 30°S in the east.
SAVE 5: January - March 1989, 2 approximately meridional sections along 41°W and 30°W between 32°S and 53°S.

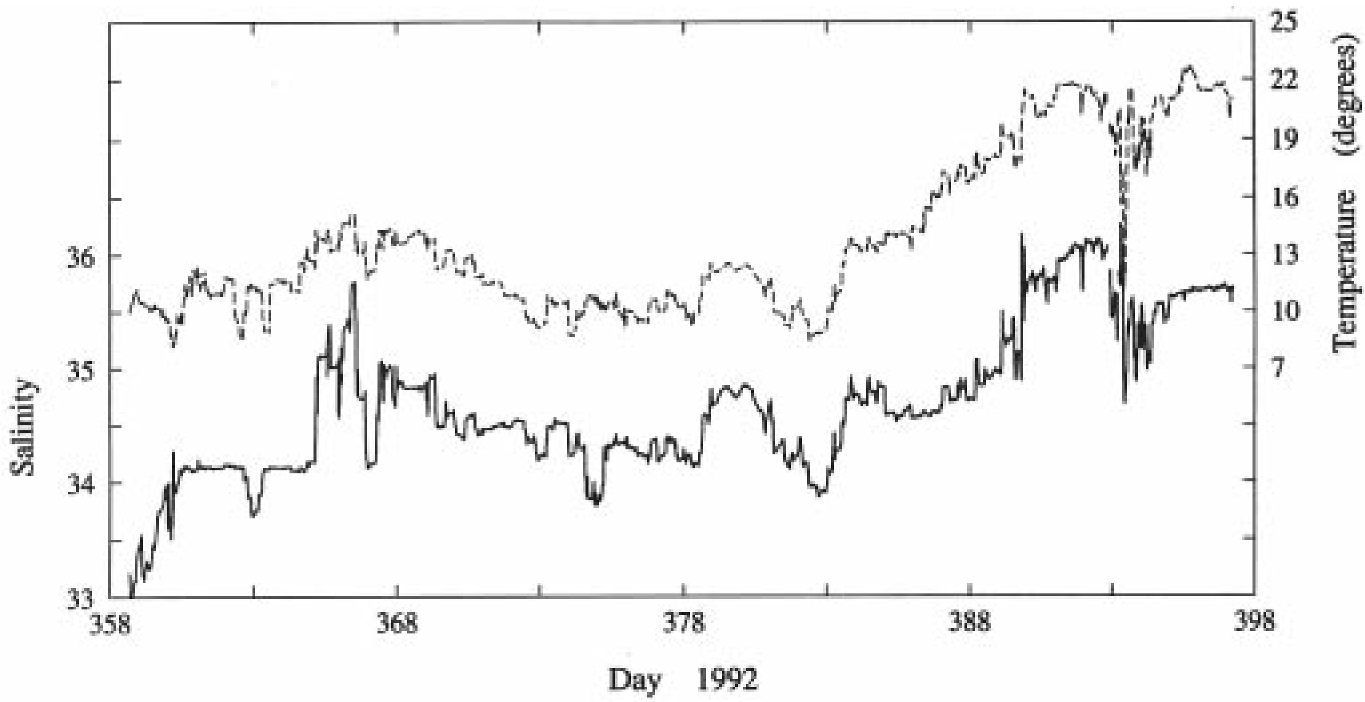

Figure 3. Surface salinity (continuous) and temperature (broken) on cruise A11. The cruise begins on the Argentine Shelf, passes through the Falkland current (day 363), enters the Brazil current retroflection (day 365), traverses the Subantarctic Zone until somewhere between day 386 and 390 it enters the subtropical gyre. The cruise ends in S. Africa.

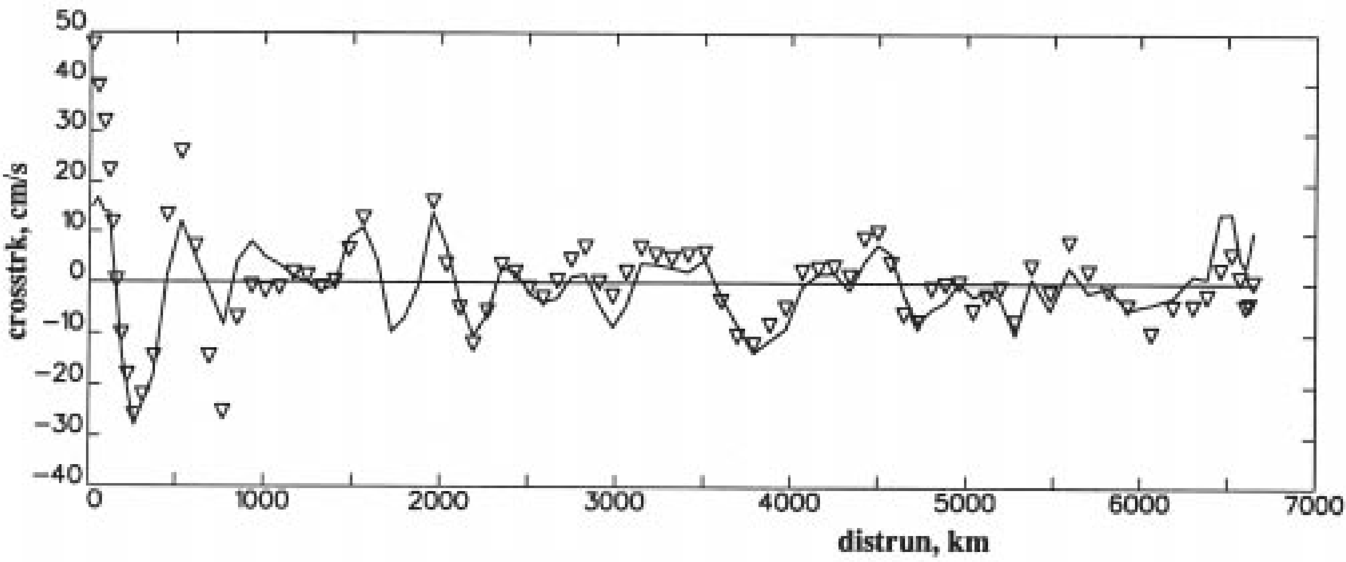

Figure 4. The geostrophic velocity relative to the bottom (continuous) and the ADCP crosstrack component (triangles). Both are determined at 100 m depth.

inferred. The consequences for transport in the WBC and exchange across the section are considerable. On the South African slope, along-slope velocities were also observed on a crossing of the Benguela Current. However these were quite small and variable in direction and a preliminary analysis suggested they were dominated by transient (tidal or inertial) components. Throughout the cruise the general agreement between geostrophic estimates and cross track ADCP currents, shown in Figure 4, is surprisingly good.

Within a few days of Discovery leaving port the German research vessel Meteor left Rio to carry out identical work on the A10 section along 30°S. The two ships docked in Capetown within a day of one another. When the two data sets are assembled exciting opportunities for new interpretation of each will occur.

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A NEW HYDROGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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In December 1992 an atlas was published, which describes the climatic hydrography of the Southern Ocean south of 30°S. It is based upon about 38000 historical hydrographic stations which have been incorporated into a database system at Alfred-Wegener-Institute for Polar and Marine Research, Bremerhaven, Germany during the last three years. The project was a joint venture of Alfred-Wegener-Institute and Arctic and Antarctic Research Institute, St. Petersburg, Russia.

Many institutions contributed considerably with their bottle and CTD data to complete this large collection of hydrographic data for the time period 1902-1991. The raw data were interpolated to the standard levels and then validated using several objective and subjective criteria (Levitus, 1982; Gordon *et al.*, 1982; Belkin, 1984). An objective interpolation algorithm (Gandin, 1963; Bretherton *et al.*, 1976) was used to compute a gridded dataset of temperature, salinity and dissolved oxygen on a 1° longitude by 1° latitude grid.

The atlas set of 82 colour plates consists of horizontal maps of potential temperature, salinity, oxygen and potential density on thirteen standard levels (see Fig. 1). For six levels maps of relative error of the objective interpolation are available on transparencies which give an impression of the quality of the gridded data. In addition maps of properties on five selected density surfaces, in characteristic core layers (T_{min}, T_{max}, S_{min}, S_{max}, O_{2min}) and at the bottom are presented. The properties are also shown for three zonal (35°S, 43°S and 60°S) and thirteen meridional sections (see for example Fig. 2). For two areas of the Southern Ocean with the best data coverage (Drake Passage-Scotia Sea, region south of Africa) the seasonal surface distributions of temperature and salinity are presented. All maps and sections are derived from the gridded data set, with the exception of the core layers, which were interpolated separately after the core layer values were determined from individual profiles.

A detailed description of the station data, the validation procedure and the objective interpolation method is included in the text. The atlas, the validated station data and the gridded data set are available through:

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UK WOCE surveys in the South Atlantic and Indian Ocean

UK has completed 5 months of WOCE cruises on RRS Discovery covering WHP section A11, the ADOX cruise which deployed 10 moorings across the Crozet-Kerguelen Gap and 6 moorings across the Princess Elizabeth Trough, and SWINDEX, which deployed 8 moorings along a line from 41°S, 29°E to 46°S, 49°E and completed 3 sections across the Antarctic Circumpolar Current. Altogether about 250 full depth CTD casts to WOCE standards were obtained, including CTD-O_2, nutrients, and CFCs, but not helium-tritium.

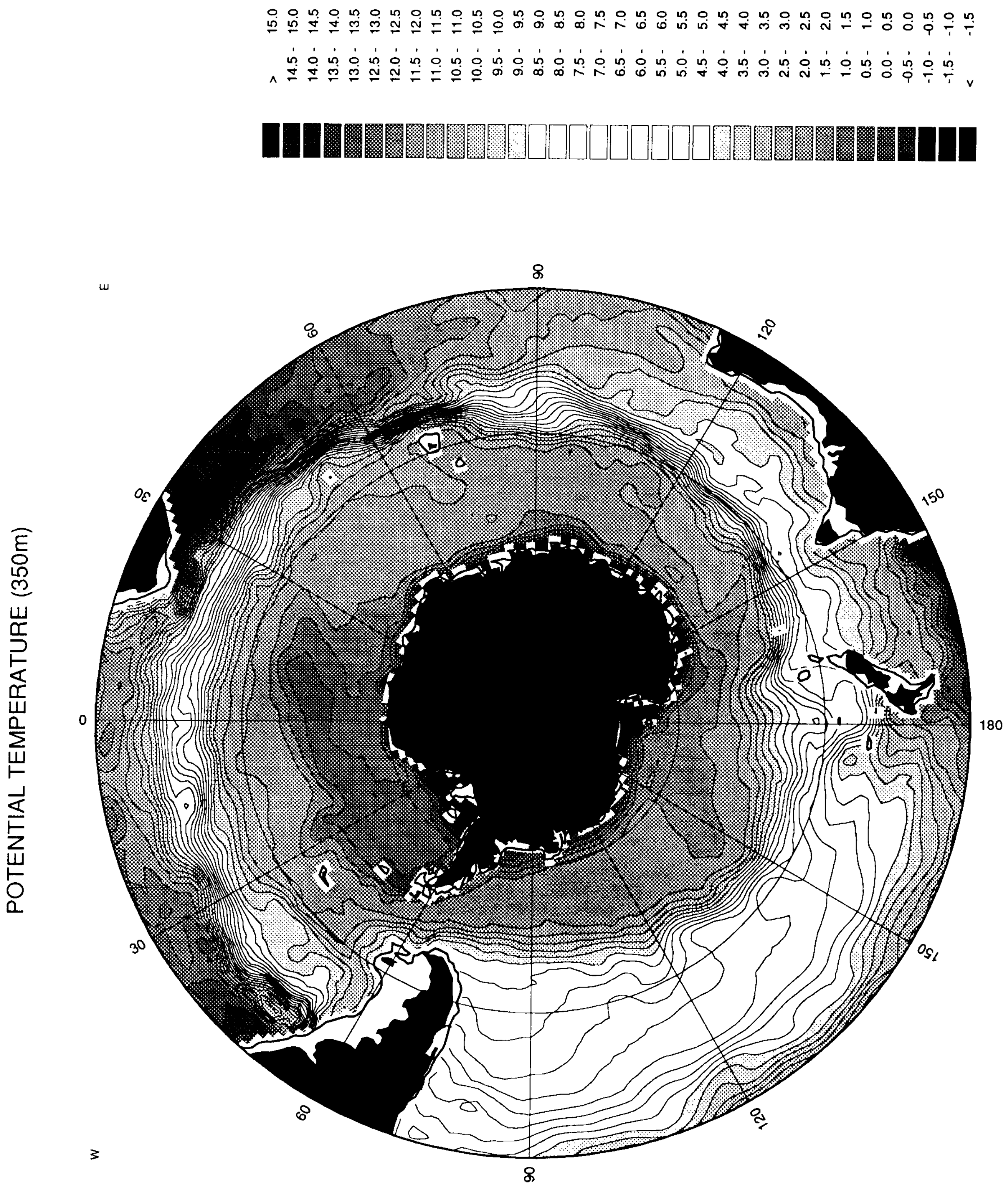

Figure 1: Example for horizontal maps on a standard layer, redrawn from the Atlas

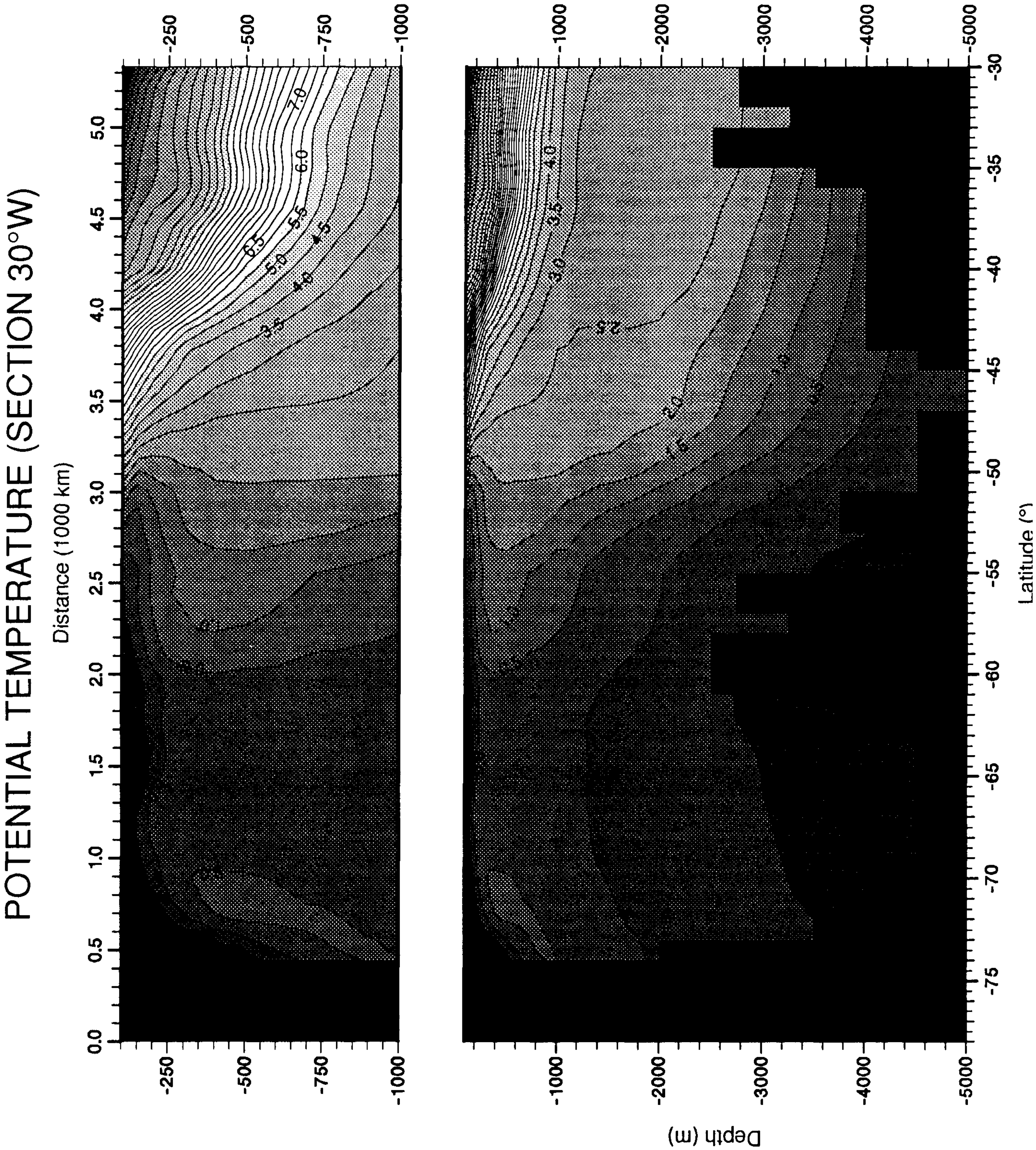

Figure 2: Example for a meridional section, redrawn from the Atlas

THE MADEIRA MODE WATER IN THE NORTH-EAST ATLANTIC SUBDUCTION REGION DURING SUMMER 1991

In Summer 1991 the Akademik Vernadsky cruise 43 was carried out, leg 2 (10 July - 3 August) of which was devoted to investigations in the northeast Atlantic, a polygon-shaped set of stations. This leg was part of the WOCE Subduction Programme in which PIs from the Marine Hydrophysical Institute of the Ukraine Academy of Sciences, Sevastopol, participate. The goal of the project is to determine movement and property distribution of the water masses for the study of processes and conditions of their formation. (For a list of all performed observations see the article by A. Kubryakov in this issue.)

The data of the CTD-surveys were used to map the large-scale geostrophic currents within the polygon of stations. Dynamic topography was calculated relative to the 700 db (reconnaissance survey, leg 1) and to the 1200 db (main survey) surfaces. Generally the currents were weak. Velocity measurements obtained using current meters from the moored buoy site (30°58'N, 23°30'W) gave results similar to the dynamic calculations. Maximum velocities of 10-14 cm/s occurred in the upper 200 m layer with predominating southwestward direction (Figure 1). At greater depths the currents became weaker and tended to be aligned zonally. The circulation between 500 m and 1000 m consisted of clockwise and anti-clockwise gyres that could be the consequence of the complex bottom relief in this region. Eighty percent of the meridional water transport was concentrated in the upper 500 metres with a southward component. The maximum of the meridional mass transport occurred across the 29°N section of the polygon and equalled 5 Sv. Total (geostrophic plus wind-driven) transport was directed to the south and equalled 3-4 Sv approximately.

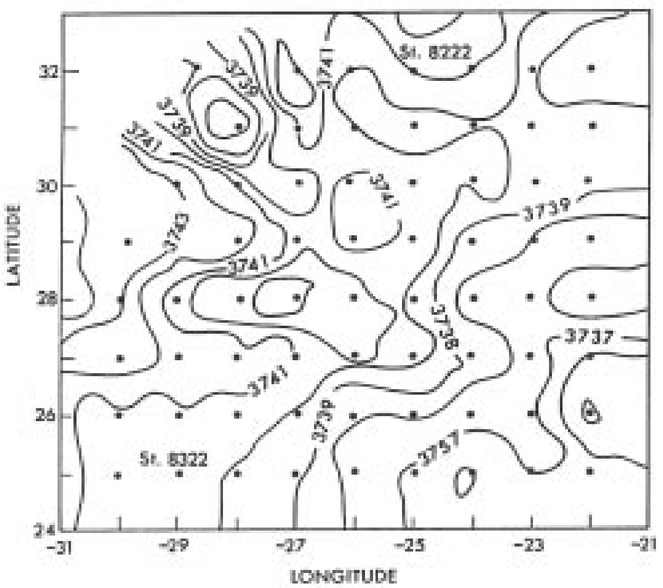

Figure 1. Dynamic topography of the 175 db surface in dynamic centimetres referred to the 700 db surface. Station positions are indicated by dots.

Both the temperature and salinity profiles reflect the upper mixed layer (Figure 2). There is coincidence of tendencies in distributions of the upper isothermal layer depth and upper isohaline layer depth. The depths of these layers increased from the north to the south and were the greatest (about 70 m) at the south-west corner of the polygon. The upper isohaline layer depth was slightly greater or equal to the isothermal layer everywhere in the area. Their difference was greatest at the south end of the polygon.

In the seasonal thermocline, situated under the upper mixed layer, the vertical temperature gradient was about 0.8°C/m. Below the seasonal thermocline a layer of low mean vertical gradient was observed, with the main thermocline below. At the base of main thermocline the Mediterranean water mass was located.

The vertical distribution of salinity was more complex. There were two maxima of salinity in the upper 200 metres. Within the main halocline the salinity decreased from 36.5-37.0 at 100-200 m depth to 35.5 at 700-800 m depth. The lowest values of salinity were observed at the central and south-west stations in the 1000-1100 m depth range (35.1-35.5). From 700 m to 1400 m salinity increased by the influence of the Mediterranean water mass. Below 1400 m salinity decreased everywhere in the study region. The absolute minimum of salinity equalled 35.0 at 2000 m depth.

Preliminary analysis of the CTD data has revealed several water masses whose interaction formed the thermohaline structure of this region. One of the particularly striking water masses is the Madeira Mode Water.

The existence of the Madeira Mode Water was shown by Siedler *et al.* (1987) for the first time. The Madeira Mode Water is the subtropical mode water of the eastern North Atlantic. Its formation region is situated near and to the north of Madeira. It extends about 500 km west and southwestward after its formation by wintertime convection and disappears almost completely before the next winter.

Propagation and transformation mechanisms of the Madeira Mode Water are poorly understood at the present time. From the data obtained in summer 1991 during the Akademik Vernadsky cruise 43 the limits of extent and characteristics of the Madeira Mode Water were specified at the time of maximum movement away from the formation region (Artamonov *et al.*, 1993).

In the 200-300 m depth range two main water masses were found in the study region. A subtropical water mass was located within the southern part of the area and had high mean temperature (>20°C) and salinity values (>37), while the North Atlantic Current Water entering from the north had lower temperature and salinity values. The interface could be found by temperature and salinity fronts between 28°N and 30°N approximately.

The Madeira Mode Water is part of the North Atlantic Current Water. It is identified by a near-homogeneous layer with minimum vertical temperature gradients in the range 17.5-18.5°C. The thickness of this layer decreased from 50-60 m at the north of the polygon to 15-20 m in the south. The main branch of this water extended along 25°W, though local formation was revealed near the eastern and the western boundaries of the polygon (Figure 3). Along 25°W the layer of low temperature gradients with temperature near 18°C the potential density surface σ_θ = 26.5 kg m^{-3} was situated in the depth range 110-130 m to the north from 28°N. At the same location there was high concentration of oxygen that points to surface origin of this water. Also, optical measurements have shown the Maderia Mode Water had lower transparency.

The Madeira Mode Water features practically disappeared south of 29°-30°N. The layer of minimum vertical temperature gradient rose to the surface while the 18°C isotherm and the potential density surface σ_θ = 26.5 kg m^{-3} sank down to 150 m depth. Here, on the spacing depth of the 18°C isotherm and potential density surface σ_θ = 26.5 kg m^{-3}, the oxygen concentration was lower than north of this latitude. Apparently the Madeira Mode Water moving from the formation region to the south interacts with subtropical surface water near 29°-30°N. The latter possesses a layer of minimum temperature gradient and high oxygen concentration too. But T-S indices of subtropical water differ considerably from T-S indices of the Madeira Mode Water. Below the subtropical surface water

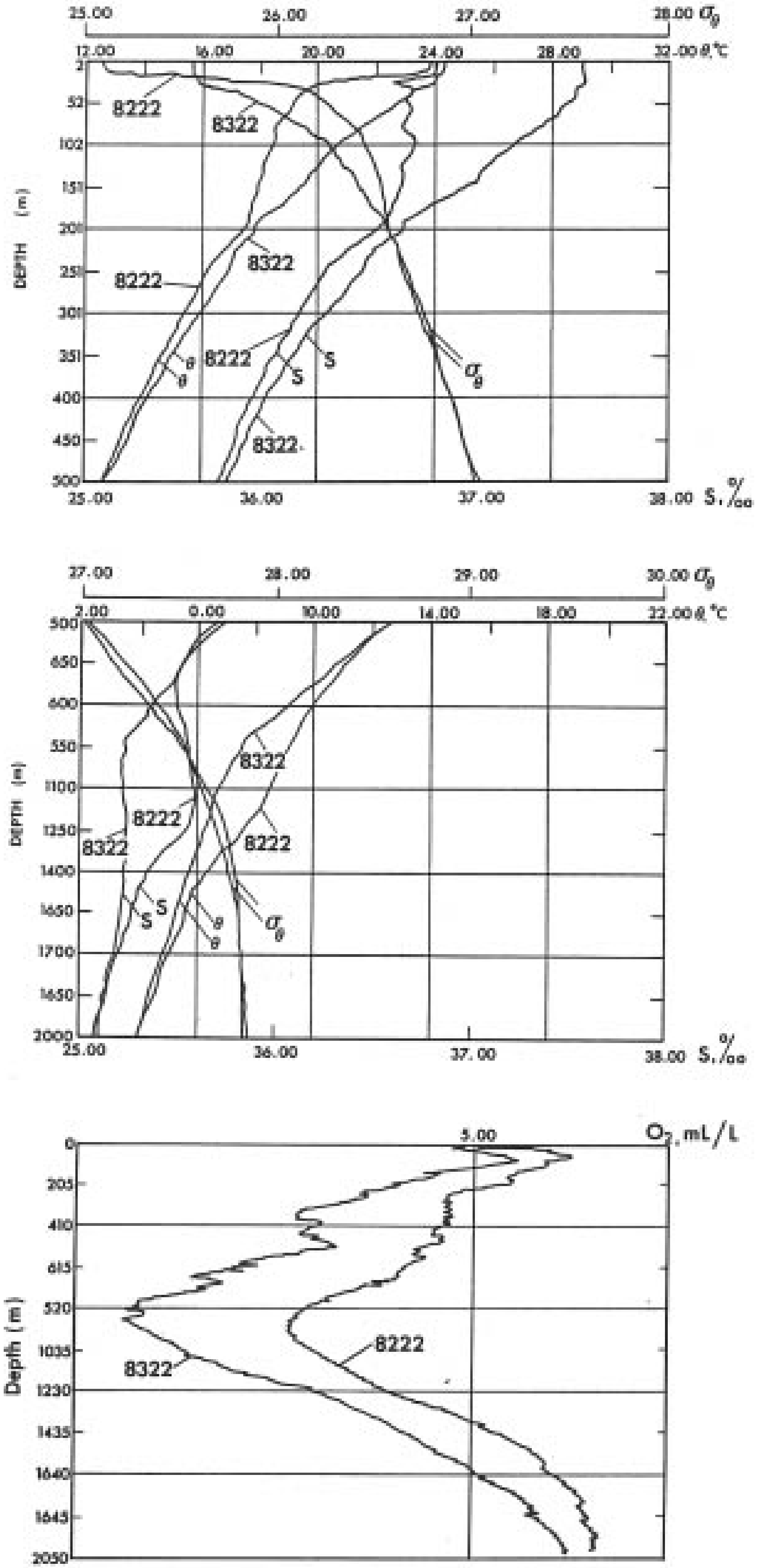

Figure 2. Characteristic potential temperature, salinity, potential density (a - in the depth range 0-500 m; b - in the depth range 500-2000 m) and oxygen profiles (c) of the northern part of polygon (Station 8222) and the southern one (Station 8322).

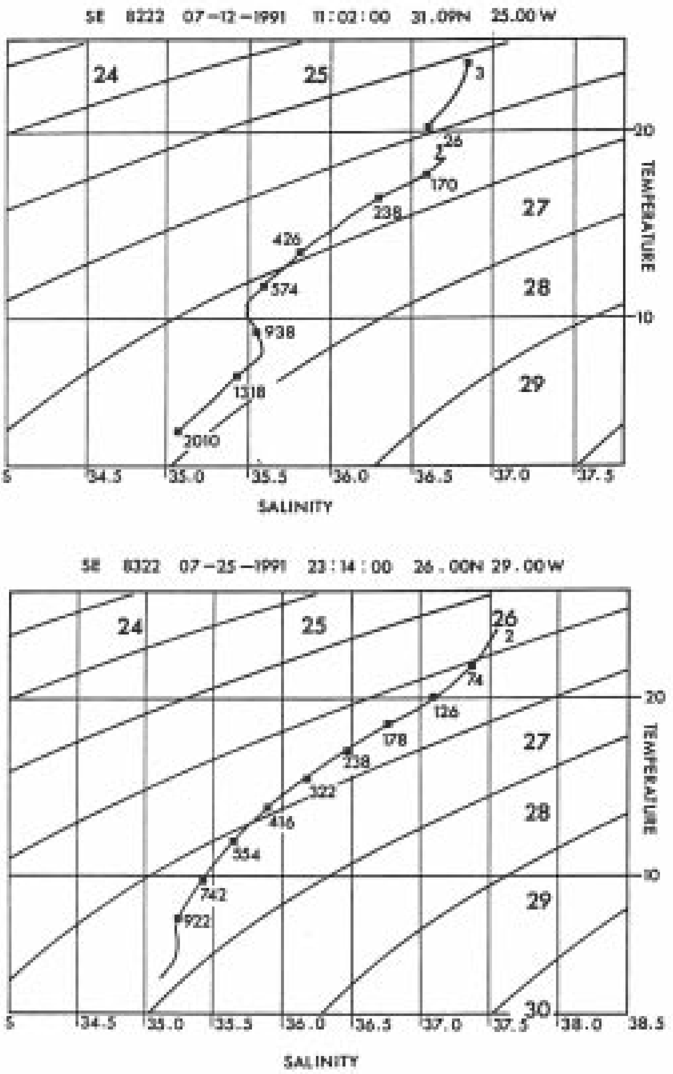

Figure 2. (d, e) T-S curves of the northern part of polygon (Station 8222) and the southern one (Station 8322).

there are T-S indices similar to the Madeira Mode Water but there is no layer of minimum vertical temperature gradient.

The spatial distribution of hydrographic properties demonstrates the same. The distributions of temperature, salinity, oxygen, density and potential vorticity minimum on three characteristic surfaces were studied: where the vertical temperature gradient, and potential vorticity were minimal, and on the potential density surface $\sigma_\theta = 26.5$ kg m^{-3}. These surfaces lie close to each other (110-130 m) in the region of spreading of Madeira Mode Water. From the observed hydrological parameters it is obvious that Madeira Mode Water was present on all three surfaces to the north of 28°-30°N. Temperature, salinity and oxygen concentrations in the region of propagation of the Madeira Mode Water were greater than those of surrounding waters.

Minimum values of the vertical temperature gradient were found along 25°W and the eastern boundary of the polygon. The regions of minimum vertical temperature gradient coincide with those of minimum potential vorticity. The horizontal distributions of temperature, salinity and oxygen concentration were similar at the depths of minimum potential vorticity and on the $\sigma_\theta = 26.5$ kg m^{-3} potential density surface. The dataset of Akademik Vernadsky cruise 43 has corroborated the existence of the Madeira Mode Water in the eastern North Atlantic Ocean. Moreover, the meridional extent of the Madeira Mode Water was bounded by the 30°N latitude. Siedler *et al.* (1987) also demonstrated a restricted horizontal extent and almost complete disappearance of the Madeira Mode Water about six months after its formation by wintertime convection. A cause of this disappearance may be the intermittent nature of subduction. The maximum thickness of the upper mixed layer (Levitus, 1982) approximately equals the depth of the core of Madeira Mode Water in the region close to 30°N. Evidently, when the Madeira Mode Water reaches 30°N, it is recaptured by the deepening mixed layer again and participates once more in the mixing process. That is to say the Madeira Mode Water participates in the process called temporary subduction. At the same time the spreading boundary of the subtropical water mass (“18°C water” of the Sargasso Sea) observed clearly by a subsurface salinity maximum is located just along 28°-30°N and coincides well with the line of disappearance of Madeira Mode Water. Thus a cause of the transformation of Madeira Mode Water may be collision and interaction with the subtropical water mass. A more detailed assessment of the causes of the disappearance of Madeira Mode Water would be possible if the survey were repeated during a later season.

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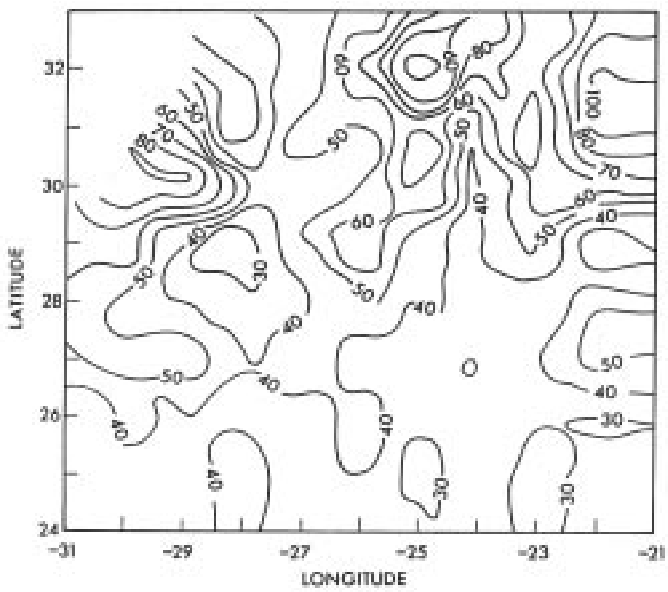

Figure 3. Thickness of the layer in the range 17.5-18.5°C of temperature (m).

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HYDROGRAPHIC AND OPTICAL MEASUREMENT STRATEGY DURING AKADEMIK VERNADSKY CRUISE 43, LEG 2: WOCE SUBDUCTION PROGRAMME

The researches were carried out in the context of the World Ocean Circulation Experiment (WOCE) during legs 1 and 2 of Akademik Vernadsky cruise 43. Leg 1 - a comparison/training exercise ("Intercalibration") - was described in brief outline by T.M. Joyce (1991). Leg 2 focussed on the "Subduction" experiment.

Specific objectives of this leg were:

- performance of large-scale polygon survey by sounding and sampling at stations using CTD-complex ISTOK-7 and between the stations while underway using towing CTD-complex MINISONDE (MHI-1201);
- performance of meteorologic observations;
- reception and processing of satellite information on water area incorporating the polygon;
- performance of survey at stations and over separate small-scale transects using CTD-complex of small structure COMPLEX-1M;
- measurement of vertical distribution of the light attenuation index in the upper ocean layer (0-300 m);
- measurement of the light attenuation index spectrum on different horizons using transparency meter;
- measurement of coefficient spectrum from sea radiance using spectrophotometer;
- measurement of the water colour index by photometer;
- determination of water transparency and chrominance by disk Secchi and Forel-Ula's scale.

The polygon "Subduction" is located in the east of North Atlantic southward to Azores (from 25°N to 33°N and from 22°W to 31°W).

The reconnaissance survey was carried out from 27 June to 7 July 1991 simultaneously with the comparison exercise. The casts were performed while underway by the device MINISONDE (MHI-1201) to 1000 m and by the complex ISTOK-7 at the stations. A total of 10 stations were occupied and 43 casts were performed during this leg.

A scheme of location of the stations and points for casts are illustrated by Figure 1.

The data on all the casts carried out during the works on intercalibration with the devices ISTOK-7 and MINISONDE is prepared on diskette in WOCE format to be passed to the American group during the call of the R/V Akademik Vernadsky in Boston.

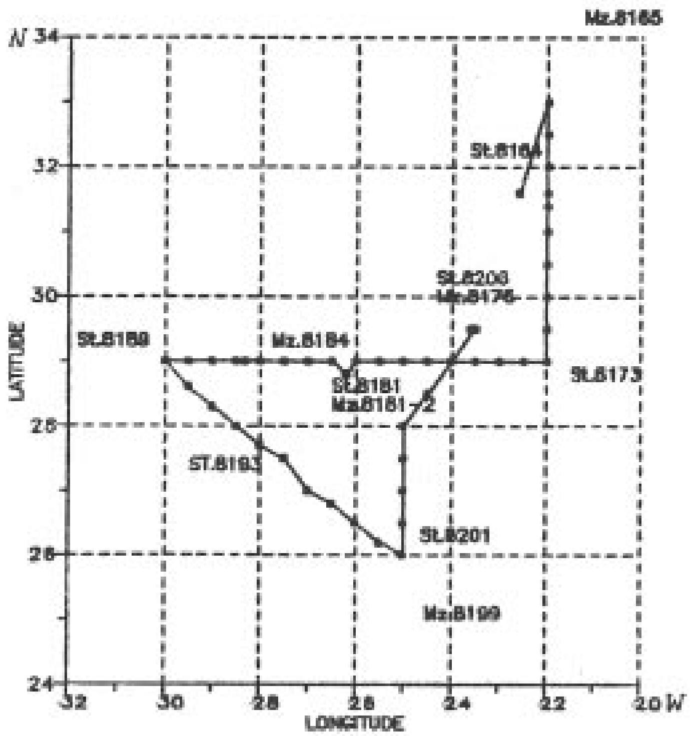

Figure 1. The reconnaissance survey of the polygon "Subduction"

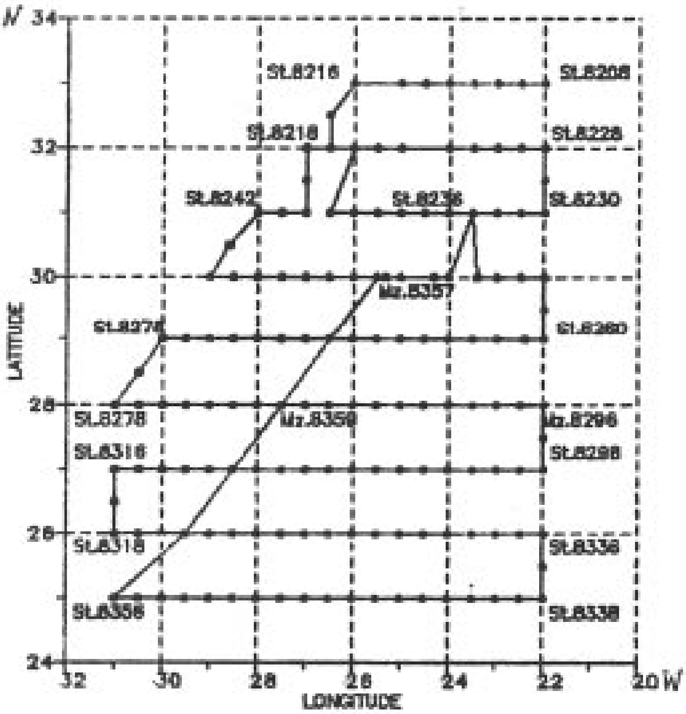

Figure 2. The large-scale survey of the polygon "Subduction"

The main large-scale and small-scale surveys were performed from 10 July to 3 August 1991.

Figure 2 illustrates the scheme of the large-scale survey. The large-scale survey comprised 75 casts to 2000 m and sampling by the CTD-complex ISTOK-7 at the stations spaced at 1 degree intervals in meridional and zonal directions and 74 casts to 1000 m by the CTD-complex MINISONDE (MHI-4207) between the stations while underway. Moreover, the additional casts were performed. All in all there were carried out 80 casts by ISTOK-7 and 157 casts by MINISONDE.

On 4 July 1991 the self-contained buoy station with temperature current meter MHI-1301 was deployed (position: 30°58.8'N; 23°30.9'W) on the horizonts: 25, 75, 125, 250, 450, 650 and 900 m. The ocean depth in this position was 5325 m.

The small-scale survey comprised casts at the stations of the polygon by the device COMPLEX-1M to the depth of 500 m and 3 drift seria in the region of buoy deployment. The first series involved 26 casts to the depth of 320 m, the second one comprised 25 casts to 350 m and the third series included 71 casts to 350 m.

During the survey of the frequent (three-hour) meteo-observations, regular reception and processing of satellite information were performed. Timely satellite monitoring included ocean surface temperature mapping, solar radiation and radiation balance with a ten-day and monthly averaging.

At the drift stations measurements of vertical profiles of radiation attentuation coefficient were performed by the autocollimation transparency meter AKP-8; sea brightness coefficient was measured by spectrophotometer. Measurements of water colour index were conducted using a photometer; water transparency and chrominance were determined by Secchi disk and Forel-Ula's scale.

The information on types and composition of observations performed during the 2nd leg is tabulated in Table 1.

On the evening of 1 August 1991 we came up to the buoy. Approaching it while underway we performed several casts to 350 m by MINISONDE. Then the vessel lied to drift. A cast to 2000 m was conducted. On 2 August 1991 during drift a set of casts to 350 m by COMPLEX-1M was carried out.

Then at 4 p.m. on 2 August 1991 the buoy was recovered. Unfortunately, due to malfunctions of the registering device the information from the third device (250 m) was not obtained, and from the fifth one (425 m) only four-hour realization was got.

Further analysis of the obtained data is needed as well as the collection of additional data for other seasons.

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Reference

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NEW: A Summary of WOCE Data Management

Quick reference to availability of WOCE data sets and their accessibility is the purpose of a new paper providing concise information on the operation of the WOCE data management system.

WOCE data sharing policy and practices, modes of data distribution by WOCE Data Assembly Centres (DACs) are described, and details on how to access the data holdings are given. The paper is available as WOCE IPO Report 104/93. It was produced by the Data Coordinator (B. Thompson) working for IPO and DIU.

This paper will form the basis of the WOCE Data Handbook to be issued later this year. It will also contain a second part consisting of an inventory of data collected and products of general interest generated from those data.

Table 1. Observations performed during the 1st and 2nd legs of the cruise

Types of observation		Time and period of observations	The number of performed works
Hydrology	Casts using the complex ISTOK-7	29.06-03.08.91	84 stations
	Casts using the complex MINISONDE (MHI-1201)	30.06-03.08.91	187 stations
	Casts using COMPLEX-1M	29.06-03.08.91	211 stations
	Measurement of velocity and direction of the current velocity vector from self-contained buoy station	14.07-02.08.91	5 horizonts
Meteorology	Urgent meteorological observations	Greenwich time: 00, 03, 06, 09, 12, 15, 18, 21 hrs. 29.06-03.07.91	31 seria
	Recording of the global solar radiation	Apparent solar time 29.06-03.07.91	31 seria
	Recording of the direct solar radiation	Apparent solar time 29.06-03.08.91	31 seria
Hydrochemistry	Oxygen	27.06-08.07.91	8 stations, 280 samples
	Oxygen	10.07-03.08.91	10 stations, 1100 samples
	Phosphates	10.07-03.08.91	80 stations, 1600 samples
	Silicon	10.07-03.08.91	80 stations, 1540 samples
Special observations	Depth of the white disk visibility	Apparent solar time 10.07-02.08.91	29 stations
	Water colour due to standard scale	Apparent solar time 10.07-02.08.91	29 stations
	Vertical profile of water transparency	Greenwich time 10.07-02.08.91	63 stations
	Spectral composition of incident and upward radiance	Day solar time 10.07-02.08.91	14 stations
	Vertical profile of the sea water colour index	Day solar time 10.07-02.08.91	10 stations
	Recording of spectral optical atmosphere thickness in the visible, near, thermal and IK-range of spectrum	Day time at a solar disk visibility 04.07-04.08.91	354 seria
	Reception and processing of solar information in visible and IK-range from satellite NOAA	2 night receptions 2 day receptions 01.07-31.07.91	78 images
	Recording of the acceleration of the sea free surface by the self-contained buoy wave gauge meter	Day time 24.06-02.08.91	352 realizations

THE XBT FALL RATE EQUATION

There has been widespread concern amongst the community of XBT users regarding the accuracy of the manufacturer's fall rate equations for expendable devices. The IGOSS Task Team on Quality Control of Automated Systems (TTQCAS) has done much work to develop a revised version of the fall rate equation. After hearing reports from the TTQCAS, the TOGA/WOCE XBT/XCTD Programme Planning Committee at their meeting in October 1992 concluded that the revised fall rate equation for T4, T6 and T7 XBT probes manufactured by both Sippican and TSK was now sufficiently well documented as to justify its adoption.

The Committee recommended that the target date for full implementation of the revised equation should be 1 January 1995, *i.e.* immediately following the TOGA ten-year observing period. The IGOSS Coordinator, with assistance from the TTQCAS, undertook to coordinate implementation. Amongst the required actions are changes to the WMO BATHY code (JJXX report) for real time transmission on the Global Telecommunications System (GTS) to accomodate information concerning probe type and fall rate equation used, and corresponding adjustments to the data centre archives and data exchange procedures. Since the October meeting the target date has been delayed to 1 January 1996 because the revision of the GTS code must be approved by the WMO Committee on Basic Systems and then by the WMO Executive Council.

Manufacturers of deck units and processing software will be urged to provide their users with the updated software and hardware necessary to implement the revised equation by 1 January 1996. The Committee strongly recommended that the fall rate equation currently in use should be maintained in all data exchanges, both real time and delayed mode, until 1 January 1996. Details concerning the revised equation and its implementation will be found in the reports of the meetings of both groups and in a scientific article on the subject to be submitted to a refereed journal in mid 1993.

JOINT VENTURES WITH THE CONFEDERATION OF INDEPENDENT STATES (CIS)

Over the past year we have seen an increasing number of offers from scientists within the former Soviet Union to provide ships and personnel for WOCE operations. Examples of recent successful, multi-nationally resourced expeditions were S4/Pacific (R/V Ioffe, Spring 1992, CIS/US), and AX3 (high density XBT section along 48°N in the Atlantic) (R/V Multanovsky, 1992, CIS/GER). Such joint ventures have enabled the Russian institutions to keep some of their research vessels operational and dedicated to further oceanographic missions. Unfortunately, successful matches of supply and demand of shiptime across east-west political boundaries are all too rare. The Russian (Ukrainian) appeals sometimes have too short a lead time which make it hard or impossible for western scientists to obtain the necessary funding in time, that often needs to cover fuel costs, port fees and per diems for crew when the ship calls into western, *i.e.* "hard currency" ports, and in some cases even funds for vessel re-fits. Nevertheless, responses to these invitations for cooperation should be made in particular by those western PIs planning work in the same or nearby regions. Such individual acknowledgements of the Russian efforts to maintain or save a reliable core of their research fleet are a testimony of good will for mutual assistance with the aim of achieving WOCE goals with a truly global outlook.

At the beginning of April IPO received the following update of Russian commitments to WOCE research in the next 2-3 years. A number of repeat surveys, and in the Indian Ocean also one-time-surveys have been cancelled and the remaining work will also mostly be only possible in a cooperative mode with western scientific groups. We would like to encourage any communication with our Russian colleagues that could lead to an accomplishment of some of the work listed below.

A short glossary of acronyms for institutes

GOIN	State Oceanographic Institute, Moscow
AANII	Arctic and Antarctic Research Institute, St. Petersburg
MHI	Marine Hydrophysical Institute, Sevastopol
IOAN	P.P. Shirshov Institute of Oceanology, Moscow
POI	Pacific Oceanological Institute, Vladivostok
DVNIGMI	Far-East Hydrometeorological Research Institute, Vladivostok

Line	Country	Ship	PI	Year	Comment
ATLANTIC OCEAN					
ONE TIME HYDROGRAPHY					
A2	RUS	Professor Multanovsky	V.P. Tereschenko	1995	GOIN
A3	RUS	Professor Multanovsky	V.P. Tereschenko	1993	GOIN
A3	RUS			1994	GOIN
A4	RUS	Professor Multanovsky	A.B. Sokov	1994	GOIN
A20S	RUS		S.K. Gulev	1994	cancelled
REPEAT HYDROGRAPHY					
AR4E	RUS		D.P. Nikitin	1992	cancelled
AR4W	RUS		D.P. Nikitin	1992	cancelled
AR5	RUS	Passat	S.K. Gulev	1991	cancelled
AR7E	RUS		G.V. Alekseev	1991	AANII
AR7E	RUS	Professor Multanovsky	G.V. Alekseev	1992	AANII
AR7E	RUS		G.V. Alekseev	1993	AANII
AR7E	RUS		G.V. Alekseev	1994	AANII
AR7E	RUS		G.V. Alekseev	1995	AANII
AR11	UKR	Vernadsky	G.K. Korotaev	1991	MHI
AR11	RUS	Schtokman	V.Kh. Enikeev	1991	IOAN
AR11	RUS	Dmitri Mendeleev	V. Zhurbas	1991	IOAN
AR11	RUS	Schtokman	Y. Ivanov	1993	IOAN
AR13	RUS	Passat	A. Kalinko	1991	cancelled
AR13	RUS	Shuleykin	A. Sokov	1992	GOIN
AR14	RUS		S. Lappo		GOIN
AR17N	UKR		V.V. Efimov	1992	MHI
INDIAN OCEAN					
ONE TIME HYDROGRAPHY					
I1W	RUS		A.S. Vasiliev	1993	cancelled
I1W	RUS		V.A. Golovastov	1993	cancelled
I2W	RUS	Akademik Vinogradov	A.S. Vasiliev	1992	cancelled
I6A	RUS	Akademik Fedorov	A.V. Klepikov	1994	AANII
17A	RUS	Akademik Fedorov	A.V. Klepikov	1994	AANII
I7S	RUS		O.P. Nikitin	1993	cancelled
I7A	RUS	Akademik Fedorov	A.V. Klepikov	1994	AANII
I8ASU	RUS	Akademik Fedorov	A.V. Klepikov	1994	AANII
I9A	RUS	Akademik Fedorov	A.V. Klepikov	1994	AANII
PACIFIC OCEAN					
ONE TIME HYDROGRAPHY					
P1W	RUS	Akademik Nesmeyanov	A.S. Bychkov	1993	POI
P1	RUS		V.V. Pokudov	1993	DVNIGMI
P11R1	RUS	Akademik Lavrentyev	G.I. Yurasov	1991	POI
P11R3	RUS	Akademik Vinogradov	G.I. Yurasov	1992	POI
P11R2	RUS		V.V. Pokudov	1995	DVNIGMI
P13R1	RUS	Professor Gagarinsky	G.I. Yurasov	1991	POI
P13R2	RUS	Akademik Vinogradov	G.I. Yurasov	1992	POI
P14R1	RUS	Akademik Vinogradov	G.I. Yurasov	1992	POI
P14S	RUS	Akademik Ioffe	M.N. Koshlyakov	1994-95	IOAN
P15S	RUS	Akademik Ioffe	M.N. Koshlyakov	1994-95	IOAN
P7W	RUS	Akademik Ioffe	M.N. Koshlyakov	1994-95	IOAN
REPEAT HYDROGRAPHY					
PR12	RUS	Akademik Ioffe	M.N. Koshlyakov	1993	cancelled
PR12	RUS	Akademik Ioffe	M.N. Koshlyakov	1995	cancelled
SOUTHERN OCEAN					
ONE TIME HYDROGRAPHY					
S4I	CIS	Professor Multanovsky	A.V. Klepikov	1994	AANII
S4P	CIS/US	Akademik Ioffe	M.N. Koshlyakov	1992	IOAN
REPEAT HYDROGRAPHY					
SR3	CIS		M.N. Koshlyakov	1993	cancelled
SR3	CIS		M.N. Koshlyakov	1995	cancelled

OBSERVATION PLAN OF THE KUROSHIO AND KUROSHIO COUNTERCURRENT SOUTH OF JAPAN

Purpose

The purpose of this programme is to carry out oceanographic observations on a line starting at Cape Ashizuri of Shikoku, Japan and extending to the south southeast (AS-Line; see Figure 1) in order to estimate the mean and fluctuation of the volume and heat transports of the Kuroshio and Kuroshio Countercurrent (namely, the western boundary current system of the North Pacific subtropical gyre). The observations are intended to be the PCM5 array of the World 0cean Circulation Experiment (WOCE) programme. Using several new observation techniques, we try to obtain absolute values of the volume and heat transports instead of their relative values, which have been mostly estimated in previous surveys. The results will be combined with results of the trans-pacific hydrographic section at 30°N (the P2 section of the WOCE programme) to be carried out in 1993-94, in order to estimate the net meridional heat transport at the mid-latitude in the North Pacific. The results will also be used to establish a realistic strategy to monitor fluctuations of the volume and heat transports of the Kuroshio and Kuroshio Countercurrent for a fairly long term.

Methods

The following observations will be carried out in the proposed programme simultaneously. See also Figure 2.

(a) Moored current meter observations: Aanderaa current meters (with temperature sensors) will be moored at eight stations in the Kuroshio region, and at two stations in the Kuroshio Countercurrent region. The meters will be set at 700, 1500 and 3000 m depths as well as near the bottom on the continental slope. Observed current velocities at 700 and 1500 m depths will be used as reference velocities in calculating geostrophic velocities from CTD and XBT data. The observed velocities at 3000 m will be used to obtain the absolute flow field at abyssal depths. The observed velocities will also be used to estimate the mean and fluctuation of the barotropic component of the transport of the Kuroshio and Kuroshio Countercurrent. The observed velocities will also reveal high frequency fluctuations, which should be eliminated from velocity data obtained by instantaneous observations using a towed ADCP or PEGASUS profiler (see below).

(b) IES observations: Inverted Echo Sounders (IESs) will be set at the bottom at seven stations in the Kuroshio region, at two stations in the Kuroshio Countercurrent region, and at one station between the two regions (at the centre of the warm water mass off Shikoku). With those observations, we will monitor the fluctuation of the baroclinic field on both sides of both the Kuroshio and Kuroshio Countercurrent in order to estimate the fluctuation of baroclinic component of the transport of those currents. The data of the IESs and from the current meters deployed among IESs will be compared with each other.

(c) ADCP observations: Acoustic Doppler Current Profilers (ADCPs; made by RD Instruments, USA) will be moored at two stations in the Kuroshio region to measure velocities in the upper layer (100-500 m depth), which will not be measured by the moored current meters mentioned above. With towed ADCPs, we will carry out upper-layer velocity cross-sections (Section II; see Figures 1 and 2) in the Kuroshio region several times in a year during the programme. The observations provide us with two-dimensional continuous sections of the absolute velocity in the upper layer (note, however, that the observed velocities include high-frequency fluctuations such as tidal currents and inertial oscillations, which have to be eliminated).

(d) CTD/XBT observations: We will carry out CTD sections (along line I) several times in a year. At least once during the programme, we will carry out a full section (lines I and II) from the surface to the bottom from the coast to the end point (25°N) of the line. We will carry out XBT cross-sections along the same two lines as frequently as possible (once a month or so) and as far to the south as possible. Baroclinic fields of the Kuroshio and Kuroshio Countercurrent will be determined from these observations.

(e) PEGASUS profiler observations: We will carry out several PEGASUS cross sections (line I) during the programme. Each section will consist of 11 profiling sites with horizontal spacing of 10-30 miles in the Kuroshio region. From these observations, we will get fairly detailed cross-sections (with high resolution in the vertical as well as the horizontal) for absolute velocity and temperature (possibly salinity as well; note again that the high-frequency fluctuations need to be eliminated). The PEGASUS observations completely depend on cooperation with the University of Rhode Island; the proposal of PEGASUS work has not yet been approved.

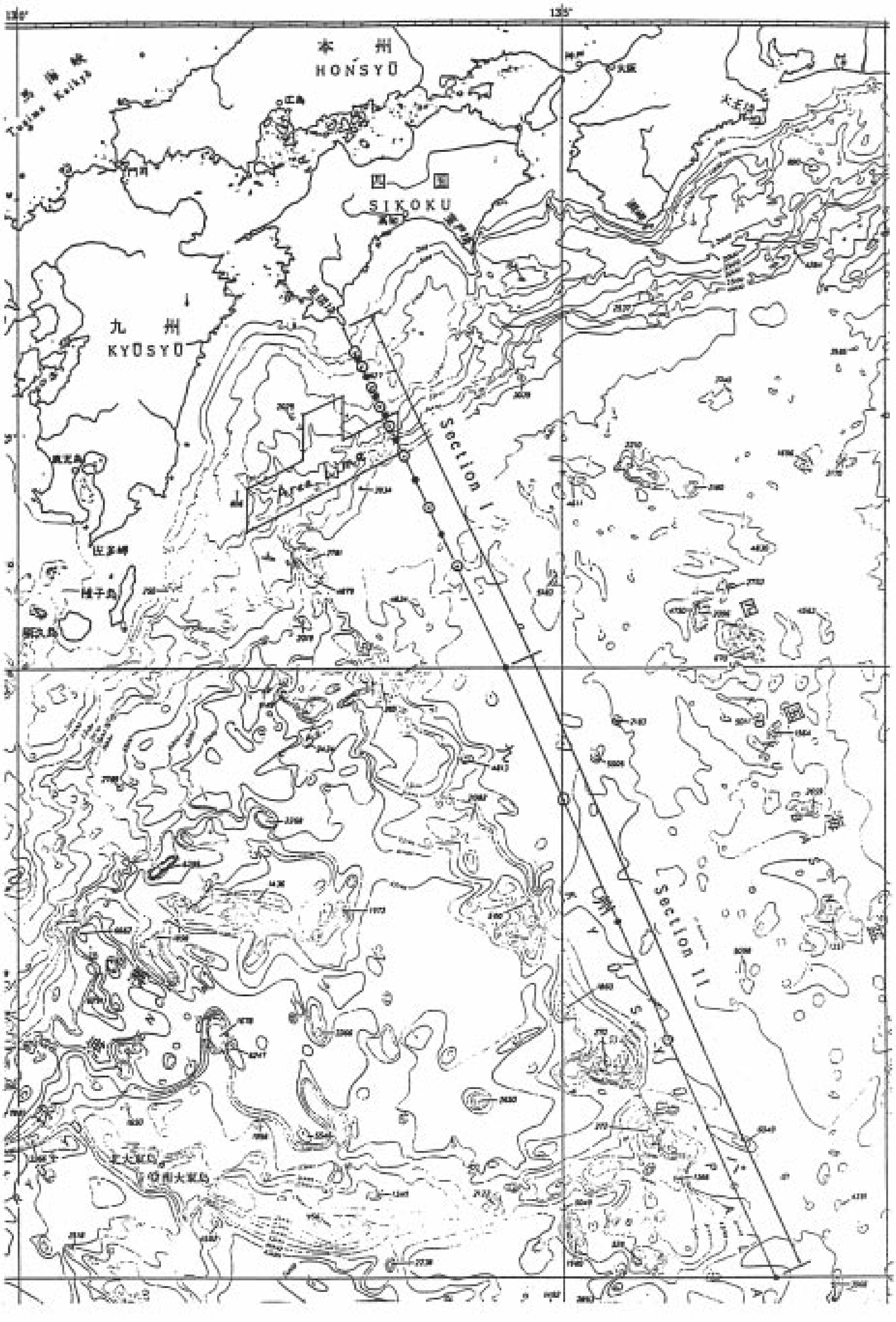

Figure 1. Location of the observation line AS off Cape Ashizuri of Shikoku, Japan. Circles show current-meter mooring sites and dots IESs.

(f) Satellite altimetry: We will use the TOPEX/POSEIDON satellite altimetry data. TOPEX/POSEIDON was launched in summer 1992, and now is providing us with time series (with 10-day intervals) of the temporal fluctuation component of the surface geostrophic velocity normal to the sub satellite track. Simultaneous hydrographic measurements or surface velocity measurements with the altimeter measurements will provide us with the basis for converting the temporal fluctuation component to absolute surface geostrophic velocity. The present observation line (AS-Line) is chosen to coincide with one of the satellite tracks of TOPEX/POSEIDON (see Figure 3). Therefore we will obtain those time series without any spatial interpolation.

Expected Results

We will use several new instruments and observation methods, which have been used rarely in the Kuroshio and Kuroshio Countercurrent regions, and plan to synthesize the data to estimate velocities, and the volume and heat transports in several different ways as follows;

(a) Velocity data from current meters moored at 700 and 1500 m depths are used as reference velocities for geostrophic calculations using temperature and salinity data obtained by CTD/XBT sections. Hence we can get absolute geostrophic velocity sections, and the absolute geostrophic volume and heat transports of the Kuroshio and Kuroshio Countercurrent.

(b) The IES data from both sides of the Kuroshio (the coastal side of the Kuroshio and the centre of the warm water mass off Shikoku) provide us with fluctuations of geopotential anomalies there, which can be used to estimate fluctuations of the baroclinic component of the transport of the Kuroshio. This baroclinic component will be combined with the velocity data described in (a), in order to approximately estimate the absolute geostrophic volume transport of the Kuroshio.

(c) Fluctuations of the baroclinic component of the transport of the Kuroshio estimated from the IES data described in (b) will also be combined with temporal changes of the sea surface geostrophic velocity (including both the barotropic and baroclinic components) obtained from the TOPEX/POSEIDON altimetry data, in order to approximately estimate fluctuations of the absolute geostrophic volume transport of the Kuroshio.

(d) The towed and moored ADCP data provide us with upper-layer (100-500 m depth) absolute velocity

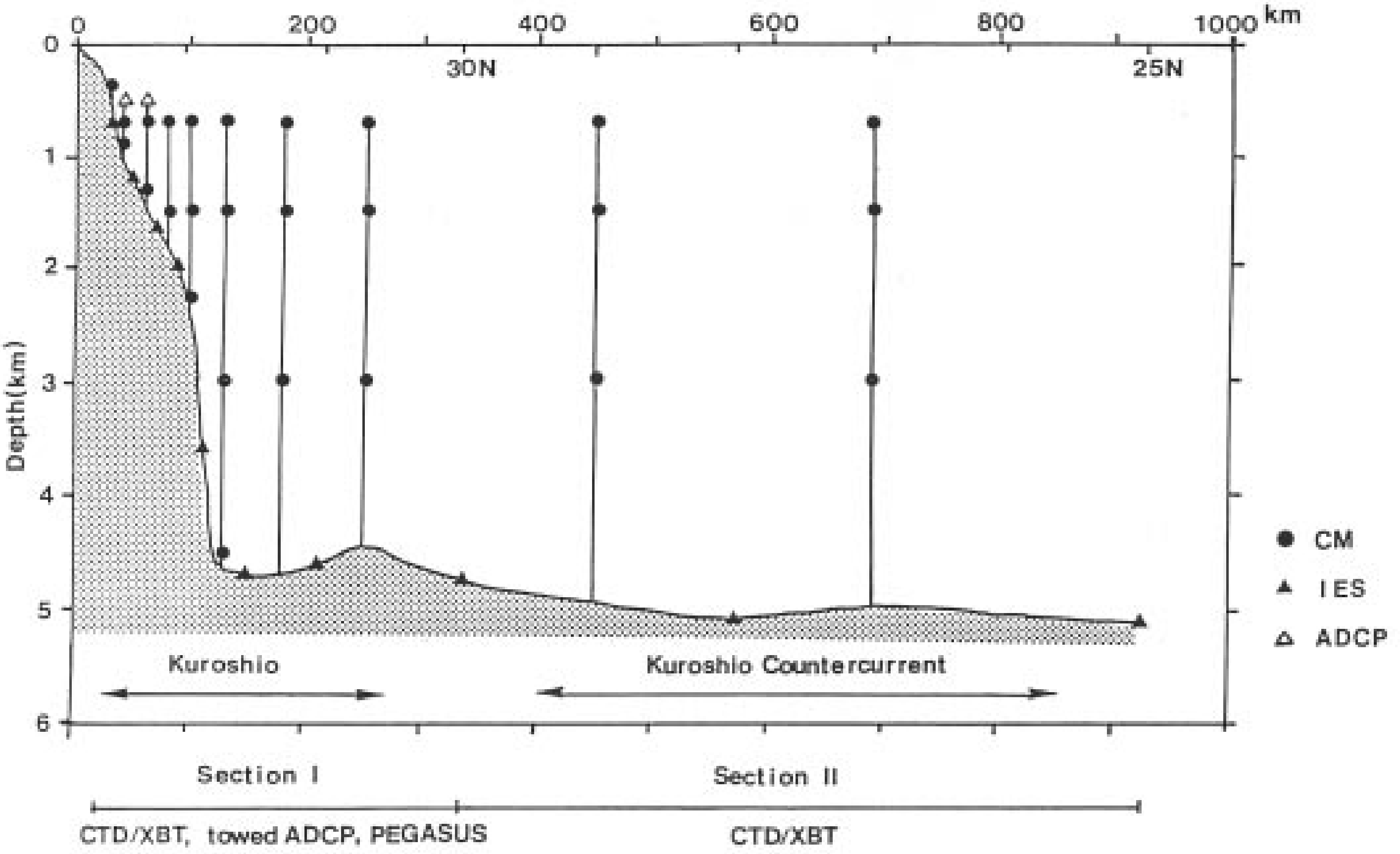

Figure 2. Vertical section of the observation line AS off Cape Ashizuri. Locations are shown of current meters, IESs and moored ADCPs as well as lines I and II for CTD/XBT, towed ADCP, PEGASUS, etc.

sections and the absolute volume transport of the upper-layer of the Kuroshio.

(e) The PEGASUS profiler observations provide us with absolute velocity and temperature (possibly salinity as well) sections from the sea surface to 2500 m depth as well as the absolute volume and heat transports of the Kuroshio.

(f) We will compare and synthesize the results obtained by these different ways mentioned above to obtain the most reliable estimates of the mean and fluctuation of the volume and heat transports of the Kuroshio and Kuroshio Countercurrent.

(g) Those estimates of the volume and heat transports are combined with data of the trans-pacific CTD section along 30°N in order to estimate the net heat transport at this mid-latitude. The trans-pacific section will be carried out in a different programme supported by the Science and Technology Agency of Japan from November 1993 to February 1994.

(h) We will assess the possibility of long-term monitoring of fluctuations of the transport of the Kuroshio and Kuroshio Countercurrent using a combination of satellite altimetry data and IES data in the way described in (c). We will determine the accuracy of estimating the temporal change of the volume transport on the basis of this combined data set.

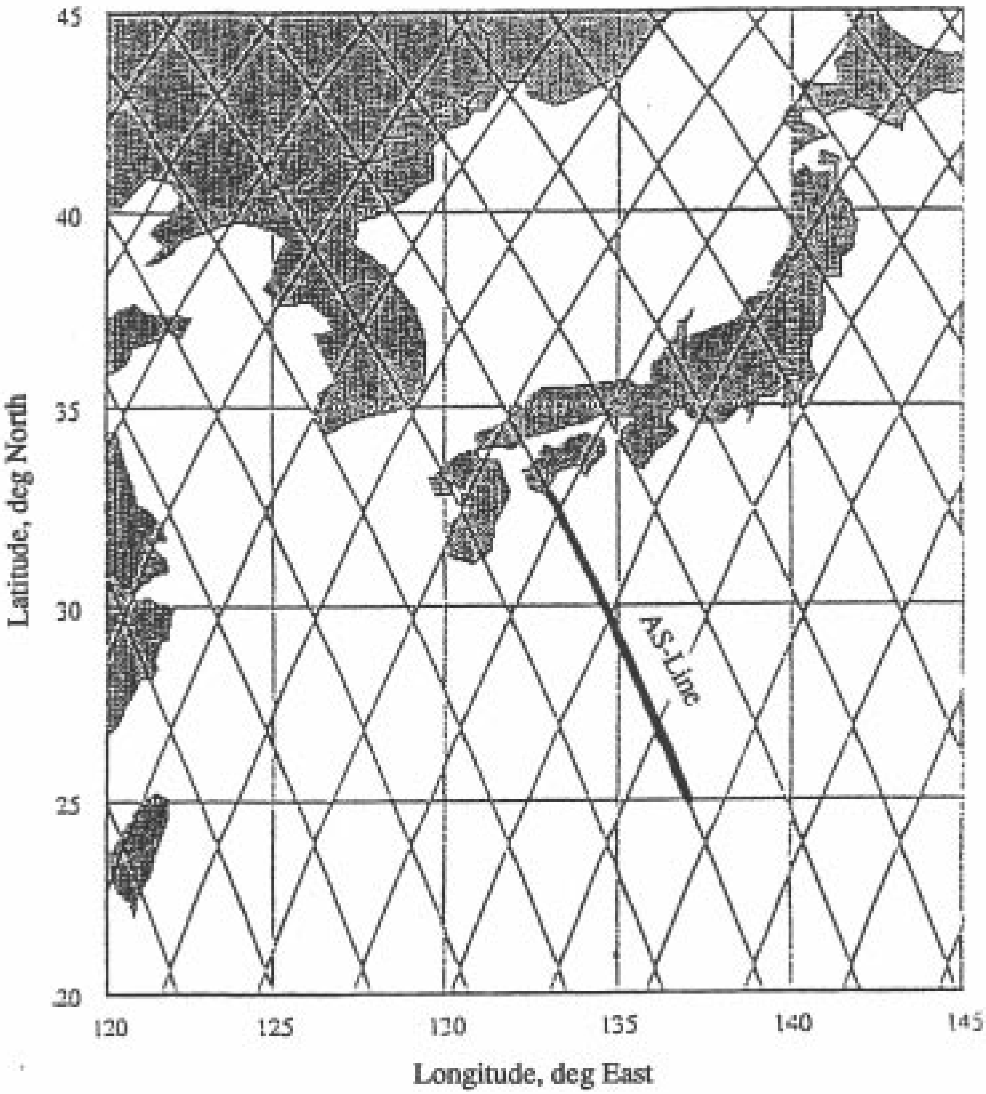

Figure 3. Groundtracks of the altimetry satellite TOPEX/POSEIDON. Superimposed is the observation line AS, located on a descending track.

Observation Area

As shown in Figures 1 and 2, we chose the observation line starting at Cape Ashizuri (32°45'N, 133°E) and extending to the south-southeast. The line consists of two sections: Section I (from Cape Ashizuri to 30°N) for the Kuroshio observations, and Section II (from 30°N to 25°N) for the Kuroshio Countercurrent observations. On Section I, instruments will be moored fairly densely, and cross-sections by CTD/XBT, PEGASUS and towed ADCP will be carried out as frequently as possible. At least once during the planned observation period, the entire section (Sections I and II) of CTD/XBT will be carried out. This line is chosen to coincide with one of descending sub satellite tracks of TOPEX/POSEIDON in order to use its altimetry data without any spatial interpolation.

The reasons why we chose the observation line off Cape Ashizuri are as follows;

(a) There, one of TOPEX/POSEIDON sub satellite tracks crosses the climatological mean path of the Kuroshio at almost a right angle.

(b) South of Japan, the location of the Kuroshio axis is most stable off Cape Ashizuri.

(c) The observation line passes through the climatological mean position of the centre of the warm water mass off Shikoku (at about 30°N), which enables us to sample the Kuroshio and Kuroshio Countercurrent most perfectly.

(d) The observation area can be accessed most easily by training vessels and research vessels of most participating universities and agencies, including

Kagoshima University, Mie University, Tokai University, University of Tokyo, *etc.*

However, the present observation line passes through a part of a manoeuvre area (Area Lima) - of US Navy (see Figure 1), and hence we might be forced to shift the location of the line slightly.

Observation Period

The observation period will be two years from October 1993 to fall 1995 (Figure 4). During the period, we will carry out observations with moored instruments including current meters, IESs and moored ADCPs, and observations on board vessels including CTD/XBT, PEGASUS and towed ADCP. Most of the instrument deployment will be carried out on board T/V Keiten-maru of Kagoshima University in October 1993. The entire CTD/XBT section (lines I and II), and recovery and redeployment of current meters will be done during the cruise (KH-94-3) of R/V Hakuho-maru of University of Tokyo in October 1994. Most of the final recovery of instruments may be carried out on board T/V Keiten-maru in fall 1995.

The altimeter aboard the satellite TOPEX/POSEIDON will measure the fluctuation of the sea surface topography for three years (possibly with extension of two years) starting in September 1992, and hence the proposed *in situ* observation period is well included in the altimeter observation period.

Background

The present planned observations have the following international aspects.

(a) WOCE PCM5: In the WOCE programme, estimating the net meridional heat transport at mid-latitude in each ocean is one of the most important tasks. In the North Pacific, the hydrographic section along 30°N latitude (P2), the western (PCM5) and eastern boundary current array (PCM2) are designed. It is strongly desired by the WOCE community that the presently planned observations of the Kuroshio and Kuroshio Countercurrent south of Japan will be carried out, satisfying requirements for the WOCE PCM5 array. The WOCE International Moored Array Panel reviewed the old version of the present observation plan and recommended to increase mooring stations and current meters for each mooring station. The present draft plan has been revised following that recommendation.

(b) TOPEX/POSEIDON: The NASA-approved TOPEX/POSEIDON group (lead by S. Imawaki) for physical oceanography in Japan will work cooperatively in the present observation plan. In the present plan, we can provide the oceanographic data for validation of the altimeter, and also try to utilize the altimetry data directly.

Observation Group

Institutes and organizations which participate in this programme include Faculty of Fisheries of Kagoshima University, Research Institute for Applied Mechanics of Kyushu University, Faculty of Engineering of Hiroshima University, Faculty of Bioresources of Mie University, School of Marine Science and Technology of Tokai University, Ocean Research Institute of University of Tokyo, Hydrographic Department, Japan Meteorological Agency, Japan Fisheries Agency, and Graduate School of Oceanography of University of Rhode Island, USA. Following is the list of participation.

(a) Current meters: Kyushu University (Imawaki, Takematsu), Tokai University (Inaba, Fukasawa), Kagoshima University (Ichikawa)

(b) IES: University of Rhode Island (Wimbush), Kagoshima University (Ichikawa), Hydrographic Department (Yoritaka)

(c) Moored ADCP: Tokai University (Inaba, Fukasawa),
Towed ADCP*: Hiroshima University (A. Kaneko, Gohda)

(d) CTD/XBT: Kagoshima University (Chaen), Mie University (Sekine), Tokai University (Fukasawa, Kubota), University of Tokyo (Taira), Hydrographic Department (Yoritaka), Japan Meteorological Agency (I. Kaneko), Japan Fisheries Agency (Acadia)

(e) PEGASUS*: University of Rhode Island (Wimbush), Kagoshima University (Ichikawa)

(f) Altimeter: Kyushu University (Imawaki)

*Observations using a towed ADCP and PEGASUS will be carried out during cruises for CTD/XBT observations as frontally as possible.

Shiro Imawaki
Research Institute for Applied Mechanics
Kyushu University
Kasuga 816
Japan

Year	Month	Measurement items							Cruises (plan)
1993	4	T/P							
	5								
	6								
	7								
	8	I			moor	tow			
	9	I	C.M	IES	ADCP	ADCP	C/X	P.G	
	10	I	*	*	*		*	*	Keiten (10/15-30)
	11	I	I	I	I	*	*		Tenyo (11/13-28)
	12	I	I	I	I				
1994	1	I	I	*	I	*	*	*	Tansei KT-94-1 (1/25-2/2), Shoyo, **
	2	I	I	I	I	*		*	Hakuho KH-94-1 (2/24-3/22)
	3	I	I	I	I				
	4	I	I	I	I		*	*	Keiten ?
	5	I	I	I	I		*		Bosei ?
	6	I	I	I	I	*			Toyoshio (6/7-11)
	7	I	I	I	I		*	*	Keiten ?, Seisui ?
	8	I	I	I	I				Nagasaki ?
	9	I	I	I	I				
	10	I	*	I	*	*	*	*	Hakuho KH-94-3 (9/?-10/20)
	11	I	I	I	I				
	12	I	I	I	I				
1995	1	I	I	I	I				
	2	I	I	I	I				
	3	I	I	I	I				
	4	I	I	I	I				
	5	I	I	I	I				
	6	I	I	I	I				
	7	I	I	I	I				
	8	I	I	I	I				
	9	I	I	I	I				
	10	I	*	*	*		*	*	Keiten ?
	11	I							
	12	I							

T/P: TOPEX/POSEIDON altimeter
C.M: Moored current meters
IES: Inverted Echo Sounders
moor ADCP: Moored Acoustic Doppler Current Profilers
tow ADCP: Towed Acoustic Doppler Current Profilers
C/X: CTD and/or XBT
P.G: PEGASUS profiler
[“-maru” is omitted in all the ship names except “Shoyo”]

** Kaiyo-maru (1/7-) and Bosei-maru (1/10-) will carry out hydrographic observations along the “Section I” as a part of WOCE one-time survey P2 (along 30°N).

SeaSoar and ADCP survey in Drake Passage

Raymond Pollard (James Rennell Centre for Ocean Circulation, UK) reports that R/V Discovery made a very successful SeaSoar and ADCP run along the Drake Passage repeat line on 12-15 November 1992. A delay in sailing meant that they unfortunately missed the ERS-1 crossing of that line on 6 November. The SeaSoar data run from 53.3°S to 60.7°S. They extend to 400 m except over Burdwood Bank (75 m on shortened cable) and south of 58.5°S (mostly 200 m on shortened cable because of fog and possible icebergs). SAMW over AAIW was found in and south of an eddy hard up against Burdwood Bank. R/V Discovery crossed the polar front at rather an angle, as currents were NE to N between 57° and 59°S, with eddies north and south of that.

THE SAMBA0 EXPERIMENT: A COMPARISON OF SUBSURFACE FLOATS USING THE RAFOS TECHNIQUE

Since the mid-seventies, subsurface floats have been used more and more frequently to follow water movements in the interior of the ocean. Until recently, these floats were of the SOFAR type, that is floats which send acoustical pulses received at moored autonomous listening stations (ALS). In 1986, T. Rossby (URI) proposed the reverse concept, that is, floats which receive the acoustical signals sent by moored sound sources. Furthermore, they surface at the end of their mission and send to the ARGOS system all the data recorded at depth.

This latter concept, named RAFOS, permits one to use an unlimited number of floats in a given area, while reducing drastically the cost and weight of each instrument.

"RAFOS" floats will be used intensively during WOCE. For our participation in the Deep Basin Experiment, we shall launch 100 such floats to tag the Antarctic Intermediate Water (AAIW) over the whole Brazil Basin. This experiment, named SAMBA after Sub-Antarctic Motions in the Brazil BAsin, will span at least 4 years from January 1994 to December 1997 and should allow us to obtain the general circulation with a 500 km resolution and a few mm s^{-1} accuracy (WOCE Core Project 1 requirements).

As a preamble, IFREMER has conducted in May 1992 the SAMBA0 experiment west of Portugal to qualify and compare all types of RAFOS floats available at that time (see Figure 1):

- ALFOS (developed by Webb Research Corp. and WHOI) and MARVOR (developed by TEKELEC and IFREMER) are multicycle floats, that is they are equipped with an external bladder which is alternately filled or emptied permitting the floats to go up or down the water column.
- The "classical" RAFOS floats are only one cycle floats which return to the surface by releasing a weight at the end of their mission at depth, and are developed in three very similar versions by BATHYSYSTEMS, IFM/Kiel and SEASCAN.
- The vertical current measuring or VCM float (developed by SEASCAN and LODYC) is also a one cycle float but it is equipped with a vertical propeller that allows an estimation of vertical velocities.

ALFOS, MARVOR and VCM all have an aluminium tubing whereas classical RAFOS use a glass tube (see figure 1).

Mooring test

ALFOS, MARVOR and VCM floats were first carefully compared by attaching them together on a mooring line, thus at the same fixed point. The 10 day recordings of T and P showed a very good agreement between MARVOR and VCM within 0.02°C and 1 dbar. On the other hand ALFOS gave pressures differing by order of 10 dbar and temperatures generally higher and within 0.1°C of the MARVOR and VCM ones. MARVOR and VCM use the same platinum resistor and PAINE strain gauge with the same processing board (manufactured by SEASCAN), and the calibrations done by SEASCAN have been checked in IFREMER Meteorology Laboratory with maximum deviations of 0.03°C and 5 dbar. ALFOS uses a thermistor (known to be less stable) which has however been calibrated in IFREMER with an accuracy of ±0.01°C and a DATA INSTRUMENT strain gauge whose calibration revealed a behaviour inferior to that of the PAINE sensor. A possible explanation for the differences between the temperatures measured by ALFOS and those measured by MARVOR and VCM is that the ALFOS thermistor is not in contact with the aluminium tubing of the float, and measures in fact the temperature of the interior air.

Acoustical signals (at 260 Hz) were sent 3 times daily by 3 standard WRC sources (located at roughly 500 km distance). The times of arrivals (TOAs) recorded by the three different floats were in good agreement since deviations did not exceed about 1 s.

After the mooring test, ALFOS, MARVOR and VCM were tested for a real mission. ALFOS 02 and MARVOR 02 had to dive to 1000 dbar, listen, surface and transmit to ARGOS three times in three days, while VCM had to cycle only once over the same 3 day period (recall that MARVOR and ALFOS are multicycle floats). ALFOS 02 did the 3 cycles correctly, MARVOR 02 only the first 2 cycles and we never heard it after this (back at the end of its 3rd cycle). VCM 17 did its only cycle correctly.

Meddy tagging

25 CTD casts done with a SEABIRD instrument between the Tejo Plateau off Lisbon and the western-most position at 40°N, 19°W revealed a strong meddy

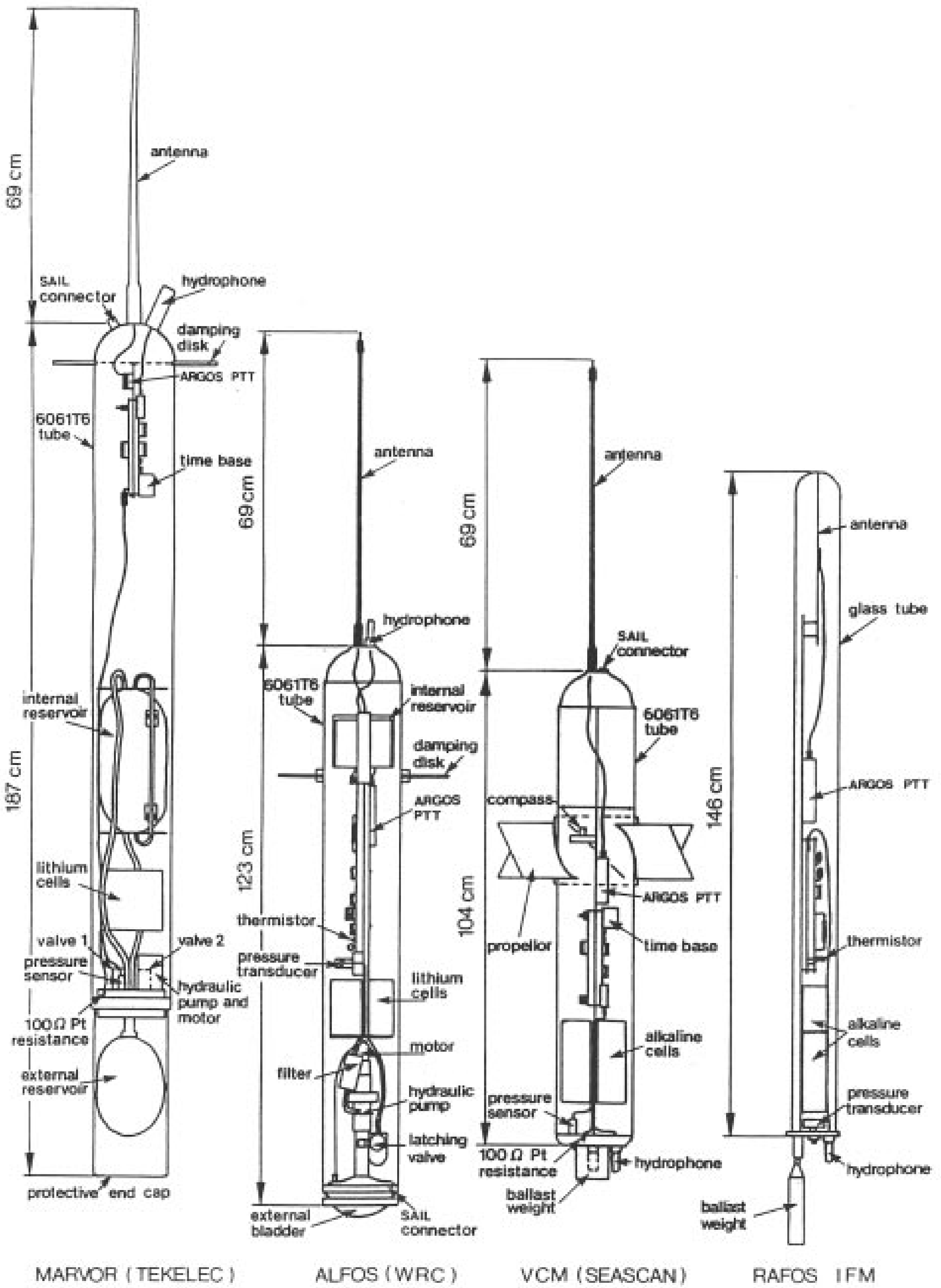

Figure 1: Schematics of the various floats tested during SAMBA0. SEASCAN and BATHYSYSTEMS RAFOS floats are not given in the figure since they differ very little from IFM RAFOS.

on 11 May 1992 near 39°20’N, 12°W (T = 12.3°C and S = 36.6 at 1200 dbar). We decided then to launch 2 of each of the different floats near the presumed centre of the meddy, for a 5 month mission at 1000 dbar depth. ALFOS 01 and ALFOS 04 were set to perform 5 cycles of 30 days and 8 hours each (27 days of listening at depth), MARVOR 03 and MARVOR 05 were to do 4 cycles of 37 days and 16 hours (35 days of listening). In addition VCM 18 and VCM 19 were programmed for a 5 month mission, and 2 RAFOS from IFM/Kiel provided by W. Zenk, 2 RAFOS from BATHYSYSTEMS provided by Y. Camus (SHOM) and 2 RAFOS from SEASCAN provided by A. Bower (WHOI) were programmed for missions varying between 2 and 5 months. As an exception to the general nominal depth of 1000 m, one of the 2 BATHYSYSTEMS floats was set for 2000 dbar.

Of the 12 floats launched, only 9 have produced a trajectory (see figure 2).

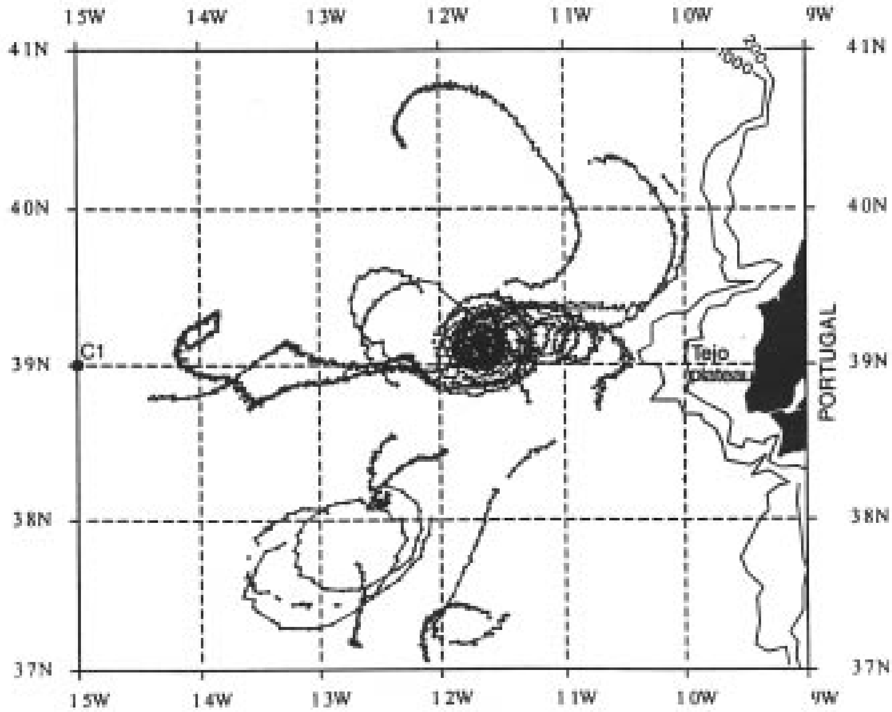

Figure 2: The trajectories obtained between 18 May and 15 October 1992 near 800-1200 m depth with ALFOS 01 and 04, MARVOR 03 and 05, VCM 19, SEASCAN RAFOS WHOI # 09, BATHYSYSTEMS RAFOS SHOM # 07 and IFM RAFOS # 31 and # 32. These floats (particularly ALFOS 01 and MARVOR 05) have revealed a strong “meddy” centred near 39°10’N and 11°45’W (rotation period of 2.5 days, trajectory diameter of 25 km and azimuthal velocity of 40 cm.s^{-1}). C1 is one of the 3 sound sources used. The two others are outside the figure. The individual float positions have been obtained from raw TOAs corrected only for sources and float clocks drifts. Estimated accuracy is on the order of a few km.

Bad results

SEASCAN RAFOS (WHOI # 08) surfaced prematurely 2 days after launch. During its short trip underwater it gradually sank down to 1500 dbar, where quite safely it released its weight. We suspect a leak, that may be due to an opening of the float, followed by a closure not done under pressure prior to launch.

BATHYSYSTEMS RAFOS (SHOM # 09) never sent ARGOS messages after its scheduled 5 month mission. Since this float was ballasted for 2000 dbar, and had been used already during a previous mission at 1000 dbar, we suspect the glass tube did not withstand the pressure, cycling glass several times under pressure, possibly causing micro-cracks.

SEASCAN VCM 18 (IFREMER) stayed in the meddy

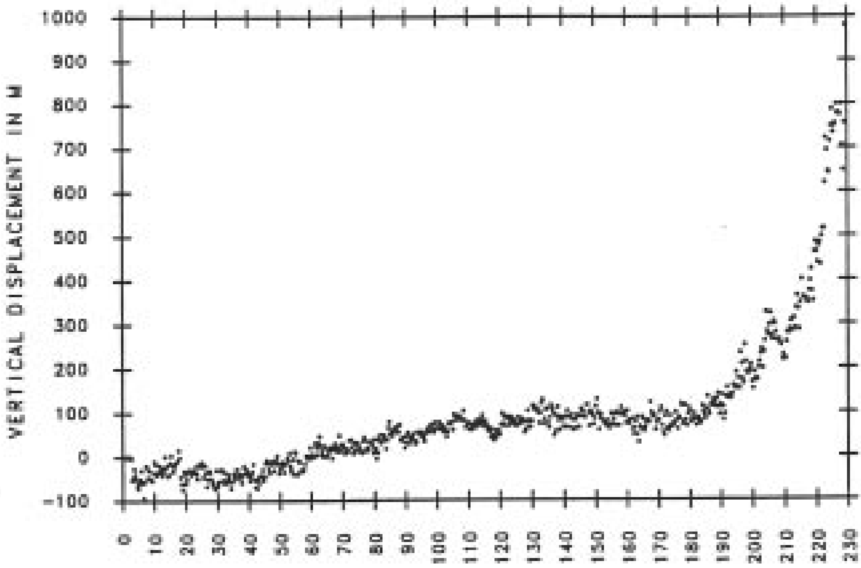

Figure 3: The absolute vertical displacement of water estimated from the difference between the vertical flow of water measured by the VCM 18 propeller and the pressure variations over the same time interval. Although we must now carefully calibrate the response of the instrument to vertical motions, the measured upwelling seems so strong (order of 10 m day^{-1}) as not to be real. VCM 19 has also measured somewhat weaker upwelling (500 metre vertical movement over 5 months). Horizontal axis is labelled in units of 8 h periods.

for 2.5 months, but unfortunately it then lost its weight and returned to the surface, at the middle of its 5 month mission. Still worse, no acoustic data was recorded, probably due to a short-circuit of the hydrophone pins (as a careful check revealed after recovery of the float).

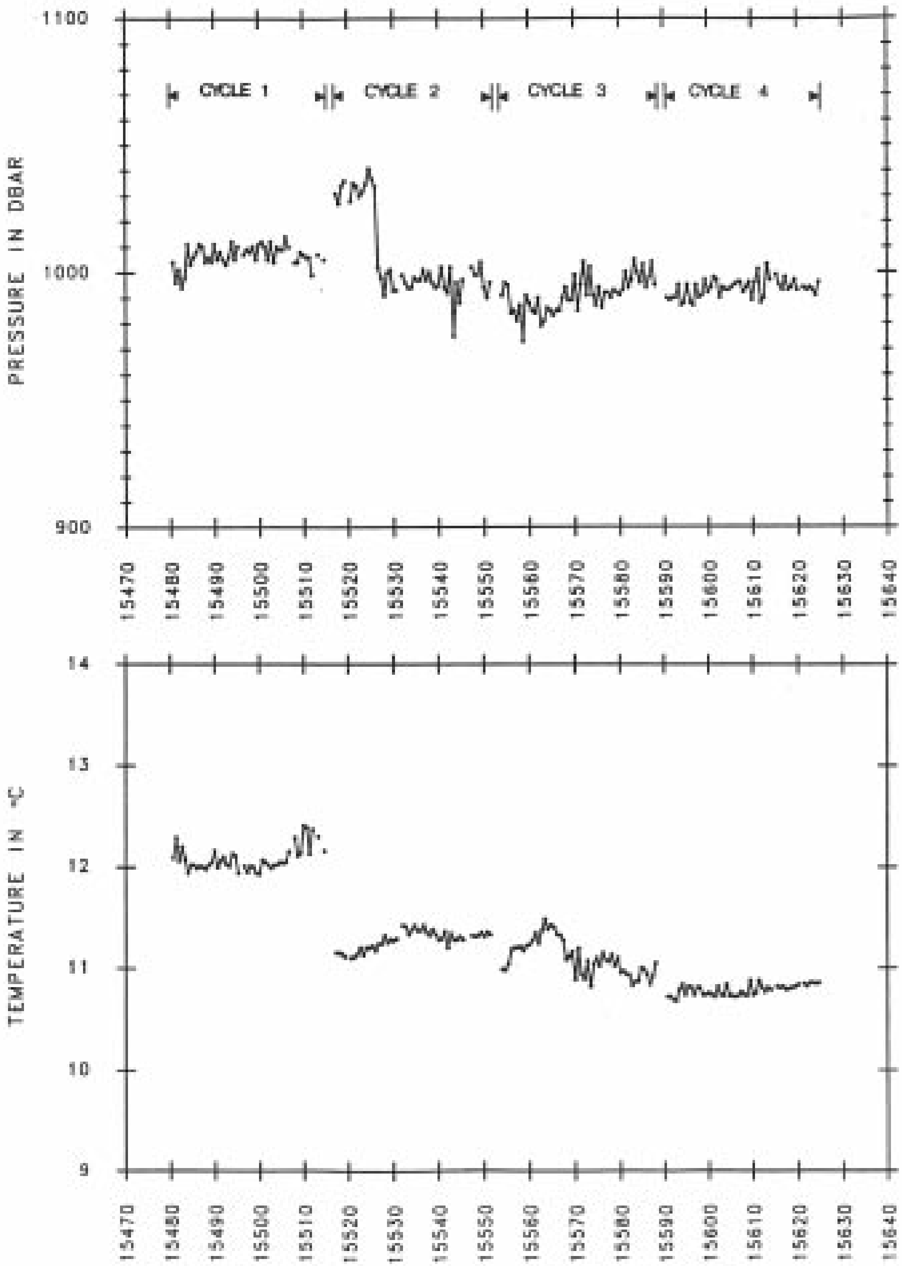

Figure 4: Temperature and pressure measured by MARVOR 05. There are 4 cycles of 37 days and 16 hours. During the first cycle the float was in the core of the meddy with over 12°C temperature, at 1000 dbar depth. Mean temperature at that depth is rather on the order of 11°C in the region, which was confirmed during cycles number 2, 3 and 4 since MARVOR 05 did dive back at 1000 dbar but outside the warm and salty eddy, having been advected at the surface during its 3 days of ARGOS transmission at the end of the first cycle. You can also notice that MARVOR did one hydraulic action during its second trip at depth: having overshot 1030 dbar, it transferred 3 cm^3 of oil into its external ballast to come back to 1000 dbar. Horizontal axes are labelled in units of days (15470 corresponds to 9 May 1992).

Good results

SEASCAN RAFOS (WHOI # 09) and BATHYSYSTEMS RAFOS (SHOM # 07) worked perfectly.

IFM RAFOS (IFM # 31 and # 32) worked also correctly, but their ballasting under pressure have probably been done less carefully than for the SEASCAN and BATHYSYSTEMS floats since these latter types of floats drifted at 1000 dbar ±30 dbar whereas the former went down only to 800 dbar (IFM # 31) and 900 dbar (IFM # 32). Of course these results rely on their pressure transducer, which is the same as the one used in the ALFOS and has been seen to be not so reliable during the mooring test (inaccuracy of at least ± 10 dbar).

SEASCAN VCM 19 (IFREMER) has experienced several 1 minute positive jumps in its clock, giving a final advance of +11 minutes at the mission's end. Fortunately this did not prevent us from getting the true TOAs. The cause of these jumps has since been identified by SEASCAN and should pose no problem in the future. Furthermore this float has measured an upwelling of 500 m of water over its 5 month's mission. An even stronger upwelling event has been measured by VCM 18: 1000 m of upwelling in 75 days (figure 3).

WRC ALFOS 01 and ALFOS 04 (IFREMER) have done properly their 5 27-day long acoustical listenings and their 5 3-day long ARGOS retransmissions. However ALFOS 01 did not go back to its prescribed depth on its third and fifth cycles. Recovery of this float has permitted to diagnose a valve misopening caused by a too short current command pulse. This will be corrected in the future floats.

TEKELEC MARVOR 03 and MARVOR 05 (IFREMER) did their 4 cycles (each 37 days and 16 hours long) perfectly (figure 4).

MARVOR 03, and MARVOR 05 together with VCM 19 (the 1 minute jumps being corrected for this latter) have very good clocks (manufactured by SEASCAN) since comparisons with ARGOS satellite

UTC time showed drifts of less than 0.1 s after 5 months. Seiko-based RAFOS and ALFOS clocks showed instead drifts of a few seconds (up to 50 s on one float) over the same period.

ALFOS and VCM floats were ballasted in IFREMER at atmospheric pressure (not in a pressure tank) which may explain the relatively poor precision obtained for their target pressure (1000 dbar) since they stabilized between 1100 and 1200 dbar. On the other hand, the 2 MARVOR floats went down to 1000 dbar within ±30 dbar naturally since they actively control their depth (1 cm^3 of oil transferred corresponds to 10 metres excursion on the vertical). Once more the results for the stabilization pressure of these floats rely on the measurements given by the pressure transducers.

Towards mid November 1992, we have recovered the 2 MARVOR, the 2 VCM and ALFOS 01, but we left ALFOS 04 in the water for further cycles. We took this opportunity to launch another MARVOR (# 04) that was programmed to cycle with a 16 days period for as long as possible. Unfortunately, after 3 cycles with fewer and fewer messages sent, it never sent any message to ARGOS at all at the end of the fourth scheduled cycle (on 11 January 1993). To be completely frank, I must also add that ALFOS 04 did not dive back at depth for its ninth cycle (probably the valve problem) and that it went too deep at the beginning of its tenth cycle, which resulted in an emergency surfacing soon afterwards on 16 February 1993.

Conclusion

This intercomparison which is the first of this kind has revealed the following: acoustical listening and ARGOS transmission are good for all the floats. Temperature, pressure measurements and time base (SEASCAN board) are very good for the MARVOR and VCM floats.

Although MARVOR seems very promising, and has a nice control of its depth, more floats must be put in water to check its long-term reliability. In fact, 3 MARVOR floats have been cycling on a weekly basis since 25 May 1993.

ALFOS floats are working correctly when the valve problem is properly solved. I would recommend however to use a better pressure transducer and to put the thermistor in contact with the end cap.

VCM are nice one-shot floats that need also to be further tested in particular to calibrate their vertical velocity estimation, which seems promising.

Classical glass-tube RAFOS one-shot floats have experienced various destinies, but their deficiencies have been well understood. I would also suggest to improve the quality of *T* and *P* measurements along the same lines as that for ALFOS.

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FLOAT GLOSSARY

ALACE	Autonomous LAgrangian Circulation Explorer
ALFOS	Contraction of ALACE and RAFOS
ALS	Autonomous Listening Station
BATHYSYSTEMS	Manufacturer of classical RAFOS
IFM	Institut für Meereskunde
IFREMER	Institut Français de Recherche pour l'Exploitation de la MER
LODYC	Laboratoire d'Océanographie DYnamique et Côtière
MARVOR	Contraction of MARCH meaning horse and VOR meaning the sea in the celtic language of old Brittany
RAFOS	SOFAR spelled backward
SEASCAN	Manufacturer of the VCM float and of classical RAFOS
SIO	Scripps Institution of Oceanography
SOFAR	SOund Fixing And Ranging
TEKELEC	Manufacturer of the MARVOR
TOA	Time Of Arrival
URI	University of Rhode Island
UTC	Universal Time Coordinated
VCM	Vertical Current Measuring float developed by SEASCAN and LODYC
WHOI	Woods Hole Oceanographic Institution
WRC	Webb Research Corporation, manufacturer of the ALACE and the ALFOS

FIELD EVALUATION OF XCTD PERFORMANCE

Introduction

Since 1988 the Bundesamt für Seeschiffahrt und Hydrographie (BSH) has operated a ship-of-opportunity line between the English Channel and the US East Coast as part of WOCE (line AX3). From the start XBT measurements have been carried out by CMS Köln Atlantic (call sign: DAKE) with a temporal resolution of about one month and a spatial resolution of 30 to 40 nautical miles.

Line AX3 crosses the subarctic North Atlantic close to the endpoint/startpoint of the thermohaline-driven Conveyor Belt (Broecker, 1987). It covers areas of pronounced processes such as the region of Subarctic Mode Water production on its eastern and central section (McCartney and Talley, 1982), or circulation patterns like the meanders and branches of the North Atlantic Current west of 30°W (Sy, 1988; Sy *et al.*, 1992), and the extreme frontal regime between the Labrador Current and the North Atlantic Current east of the Grand Banks (Clarke *et al.*, 1980). All these features are candidates for global change indications, because the stability of the North Atlantic part of the Conveyor Belt has recently been questioned on the basis of paleoclimatic investigations and results from numerical ocean models.

Temperature measurements, if sampled frequently enough, can give an idea about space and time scales of variations strongly tied into the global thermohaline circulation. But because of the variable T/S relationship in the western North Atlantic (Emery and Dewar, 1982), XBTs alone do not satisfactorily meet the requirements for investigation of changes in climate-relevant processes. In spite of the shortfalls we found in our tests of XCTDs, we recognise the great benefits that improved probes will have for systematic T/S sampling in the ship-of-opportunity programme. This brief introduction shall emphasize the need for systematic T/S sampling, using ship-of-opportunity programmes, and conclude that there is an urgent need for the use of XCTD probes.

The first transoceanic XCTD section (February 1992)

The first ocean crossing XCTD section was probably carried out by CMS Köln Atlantic (gross tonnage: 39,000 tons, length: 240 m, speed: 19 knots) from 22 to 26 February 1992 (Figure 1). The section was repeated in July 1992. All XCTD measurements were carried out by a scientist from the vessel's stern (launch height: 10 m). For data

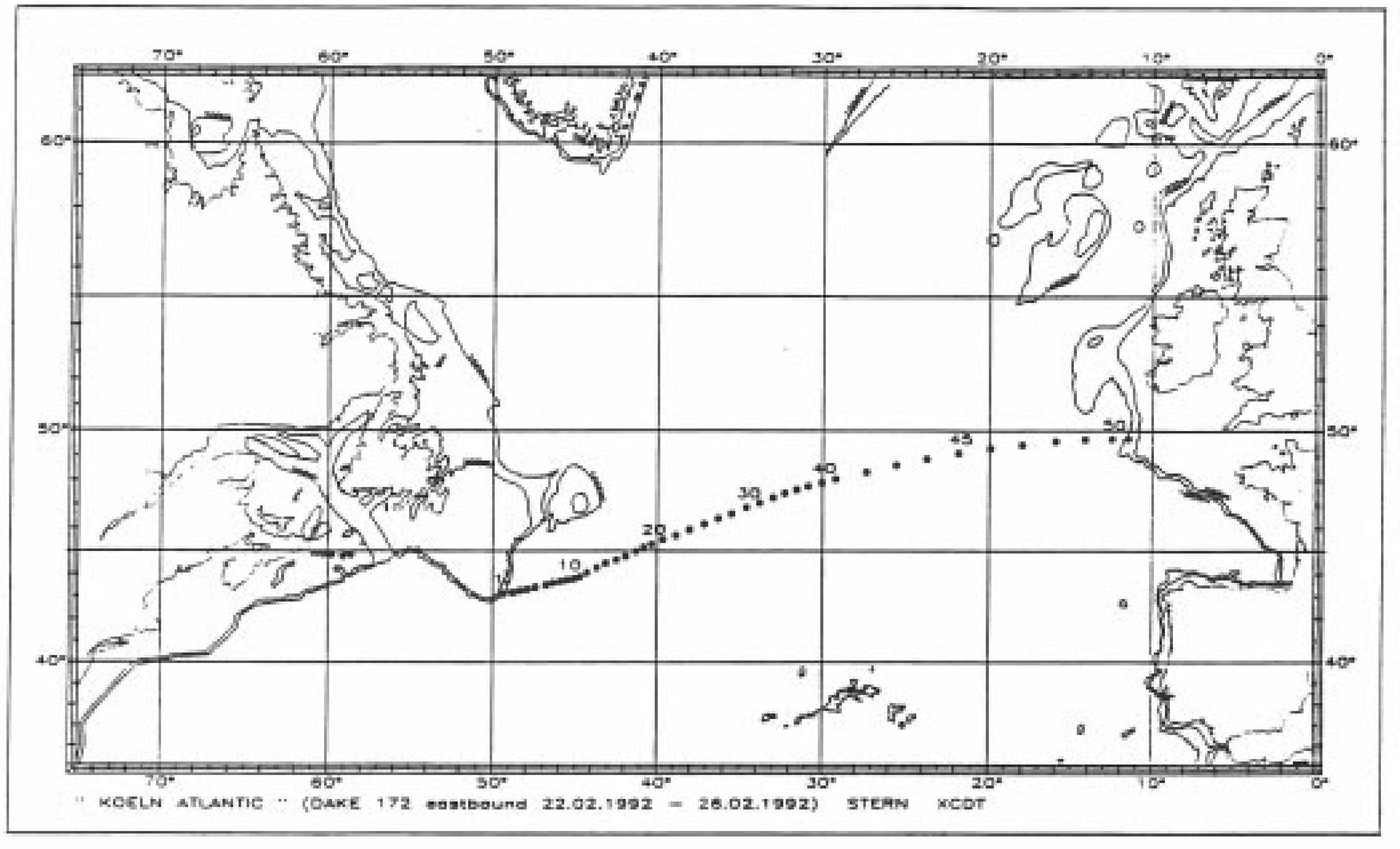

Figure 1: Track plot of XCTD profiles collected in February 1992 onboard CMS Köln Atlantic.

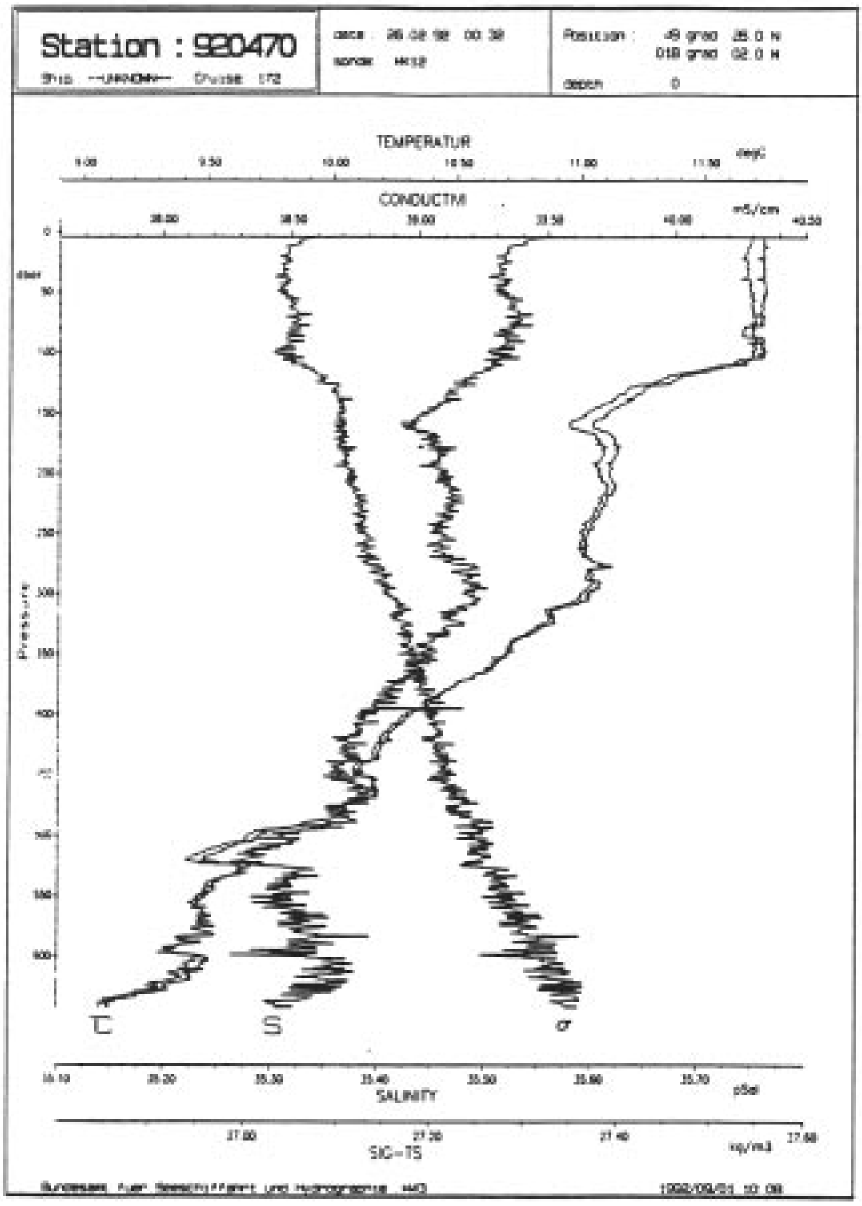

Figure 2: Example of a single XCTD measurement.

acquisition, two Compaq SLT/286 laptop computers equipped with Sippican MK-12 interface rev. E and software rev. 1.3 were used. During the February cruise, two versions of XCTD probes were launched: a 10 knt standard version, purchased from Sippican in October 1991 and calibrated by Sippican in October 1991, and a 18 knt special version provided by Sippican for test purposes (calibrated in February 1992). The manufacturer claimed that the special probes were capable of covering the upper 1000 m at a ship's speed of 18 knots - an important requirement for most ship-of-opportunity programmes.

In the MK-12 user's manual (Sippican, 1991), it is noted that for most probe types a proper seawater ground is needed and that the actual resistance necessary depends on the type of probe being used. However, it was found that XCTD operation is extremely sensitive to a good seawater contact. We searched for a suitable seawater ground by drilling a hole in one of the vessel's frames, polishing the steel at the hole until it gleamed, and mounting a thick copper ground wire with a brass screw as tightly as possible to reduce the transition resistance to a minimum. On the July cruise the grounding site had to be repolished carefully because even the smallest rust particles increased the transition resistance beyond a critical limit. Presumably, this ground problem is not peculiar to Köln Atlantic, because on RV Valdivia in September 1992 we were affected by the same problem when testing XCTDs in a bucket. Our experiences led us to believe that for ship-of-opportunity purposes XCTD probes are too sensitive for a seawater ground. There are reasons for the assumption that insufficient seawater ground caused noisy test profiles collected by some investigators.

In February 1992, 40 XCTD probes were launched of which 4 failed. During the July cruise, 45 probes were launched and 5 probes failed. This failure rate is similar to that of XBT probes. Inspection of the probes or of what remained after a drop gave some indications of tangled wire spooling. It will come as a relief to the worried user to know that Sippican has promised to replace its expensive probes in case of failure (Jim Hannon, Sippican, pers. comm.).

18 knt XCTDs were launched side by side with 10 knt probes or with T-5 (Fast Deep) XBTs, respectively. Depending on the ship's speed and the relative wind velocity, the 10 knt probes covered a depth range of 600 to 650 m only. The 18 knt probes failed completely. Their true depth fall rate was much slower than calculated and varied from probe to probe. A possible explanation might be hydrodynamic instability of the underwater body. The noise level in the 18 knt records is higher than in the 10 knt records, and for both probe types there is an increase of noise with depth (Figure 2). A staggering or a capsizing probe does not guarantee a regular (high and constant) flow rate through the conductivity cell. At low flow rates, circuit heat dissipation may heat the water near the sensor's surface.

XCTD data processing turned out to be a frustrating trial and error game due to several incorrect conversion formulas given in Appendix D of the MK-12 user's manual. The vertical resolution of raw data is about 0.8 m. Unfortunately we needed to use some effective noise and spike rejecting procedures as median filtering (Sy, 1985), followed by smooth filtering and interactive screen editing, which reduced the vertical data independency to about 10 m. In 5 profiles erroneous segments (signal disturbances) of up to 100 m had to be removed completely. Some records contained doubtful wave- or step-like features. Again, it is thought that these structures could be an indication of stability problems of the falling probe.

Finally, some brief remarks on time-lag issues. Usually the temperature sensor has a slower response than the conductivity cell. For that reason the specific sampling sequence (temperature prior to conductivity, 4 cycles per second) shall compensate the time-lag error (D. Kaiser, pers. comm.), provided that the flow through the cell is constant. Theoretically this condition should be fulfilled for free-falling probes, because they are unaffected by ship's movements. Presumably the time-lag has been overcompensated by the manufacturer. In some cases a significant noise reduction of salinity occurred by slowing down the temperature by 80 ms. On the other hand we were not able to reduce the time-lag-induced noise generally, *i.e.* for all profiles in the same way. We assume that the flow rate varies (depending on the probe's stability). We did not, however, systematize the time-lag problem further.

Admittedly, the results obtained are not quite the scientific data base we had hoped for, and it must be regarded as preliminary as long as the data quality in terms of accuracy and reliability isn't completely known. Nevertheless, we conclude that the result should not be discouraging because:

1. comparison of the XCTD temperature section *vs.* the XBT temperature section shows good agreement (Figure 3a, b);
2. the detection of signal errors is much easier for T/S data than for temperature data alone which, incidentally, has led to the decision to delete XBT drop No. 6 in Figure 3b;
3. the spatial range of salinities between their minimum in the Labrador Current regime and their maximum in waters west of the English Channel differs by more than 2 psu, and the temporal vari-

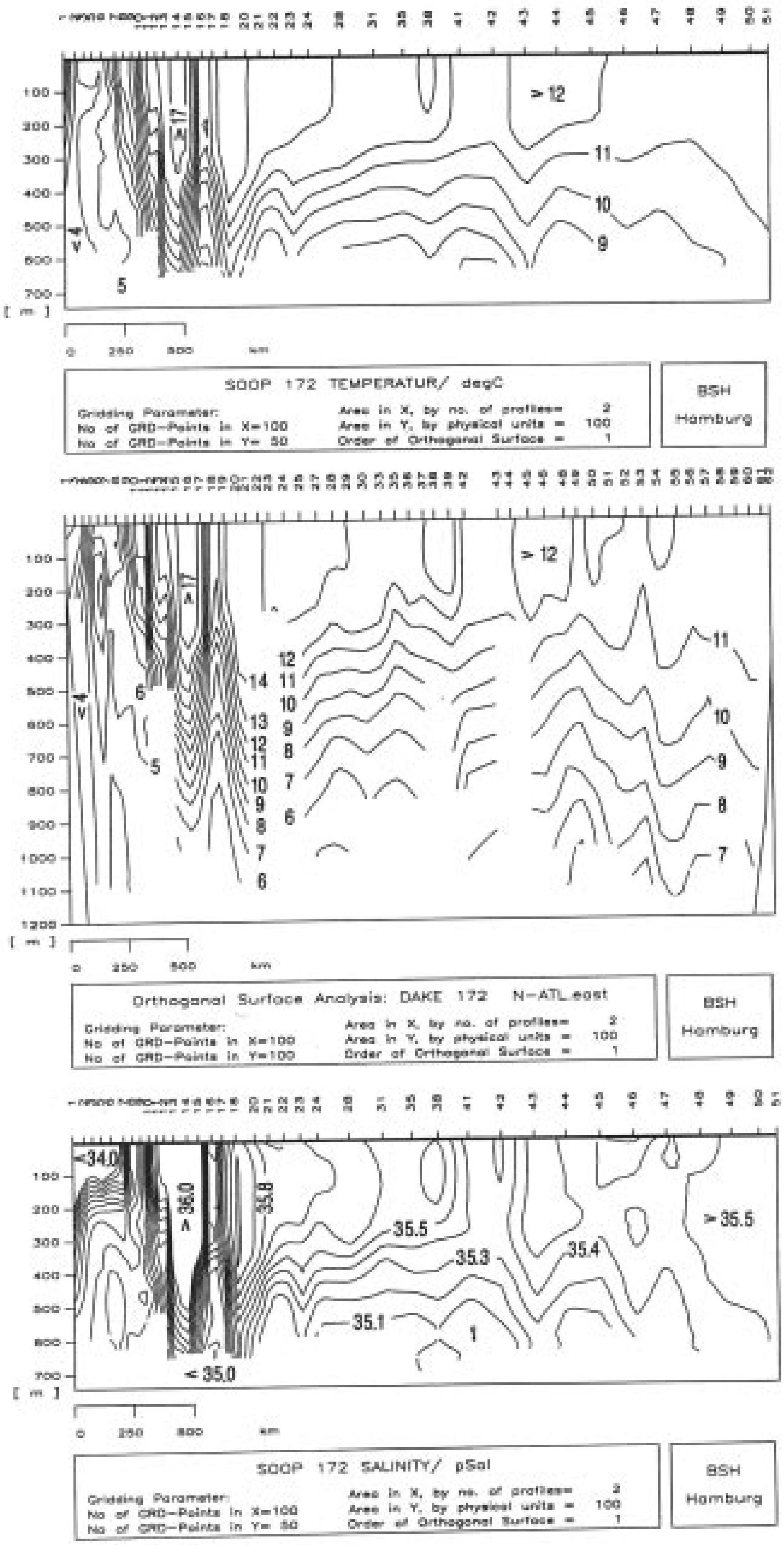

Figure 3: Section plots of <u>*Köln Atlantic*</u> *measurements in February 1992: (a) XCTD temperature: (b) XBT (T-5 "Fast Deep") temperature. XBTs were launched from the bridge's wing: (c) XCTD salinity.*

ability in the upper ocean can be expected in the order of several tenths of psu (Levitus, 1989). Figure 3c shows a reasonable salinity distribution.

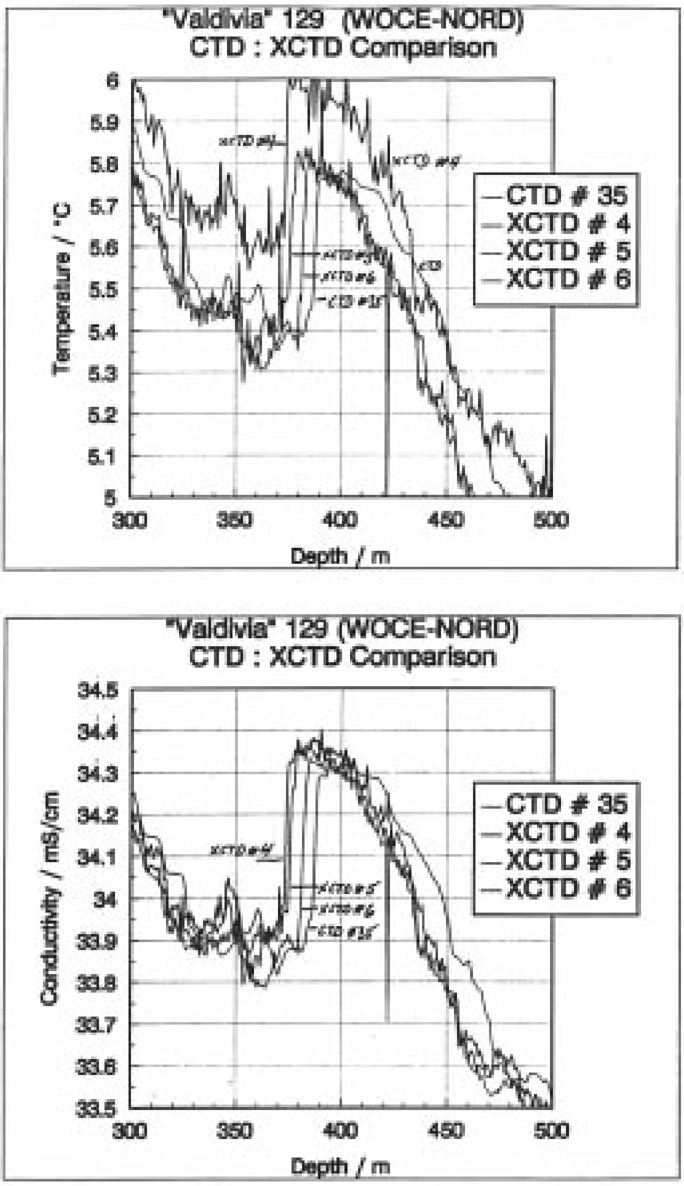

Figure 4: (a) Temperature between 300 m and 500 m at CTD No. 35. One record (XCTD No. 4) has an offset of +0.2°C. (b) Conductivity between 300 m and 500 m at CTD No. 35.

XCTDs *vs.* CTD intercomparison (September 1992)

Fortunately we were able to carry out XCTD *versus* CTD comparisons during a WOCE cruise onboard RV Valdivia in September 1992 in a region west of the British Isles, which is a good test site for expendable probes due to well developed structures in both temperature and salinity. The XCTD data acquisition system was the same as that in February. For this comparison 12 XCTDs were launched, 3 of which remained from the batch used in February and 9 came from a batch purchased in July 1992 and calibrated by Sippican in June 1992. The comparisons were carried out at 3 regular CTD stations, side by side with a well calibrated NBIS MK-III CTD. 2 drops failed due to broken wire (no signal, October 1992 batch) and 1 probe had no contact with MK-12 (June 1992 batch). The system's accuracy for XCTD measurements is given by Sippican as ±.03°C for temperature, ±.03°C for temperature, ±.03 mS/cm for conductivity, and ±5 m or 2% for depth. The results of the remaining 9 successfully launched probes are summarized as follows:

- Two measurements revealed calibration failures. One temperature record has an offset of about +0.2°C (Figure 4a) and one conductivity record has an offset of about -0.3 mS/cm (Figure 5b). On the other extreme the result from the remaining probe from the October 1991 batch corresponds well for temperature, conductivity, and depth with the CTD data so that Sippican's specifications are met in this case.
- As an overall result the range of temperature difference between CTD and XCTD was found to be about ±.06°C, and the range of conductivity difference was found to be about ±.05 mS/cm.
- As for XBT probes the XCTDs (June 1992 batch) fall faster than specified (Figures 4 and 5). The error was estimated between 3% and 4%.
- Probably due to compensation effects, the salinity deviation was found to be not larger than .05 psu (for 7 records). Salinity deviation, however, increases with depth because the fall rate formula underestimates the depth (Figure 5c). On the other hand, this salinity difference is underestimated because Sippican uses a standard conductivity C(15,35,0) = 92.921 whereas we use for CTD data the value 92.914. Finally, it should be noted that the numerical precision of XCTD salinity data is only .01 (Figure 5c). Thus salinity accuracy is affected by truncation errors.
- As in the February records, the noise increase with depth is apparent in several records. Another effect appeared which was not observed before. At 900 m depth there is a significant offset in salinity and density, which is caused by a shift in conductivity (Figure 5b).

Conclusion

As is usual for new oceanographic devices, it is not surprising that the field evaluation of XCTD performance reveals some discrepancies between theory and reality. The test results conclusively show that XCTD probes do not meet the manufacturer's specification. Furthermore, some problems occurred which need to be solved urgently. First of all,

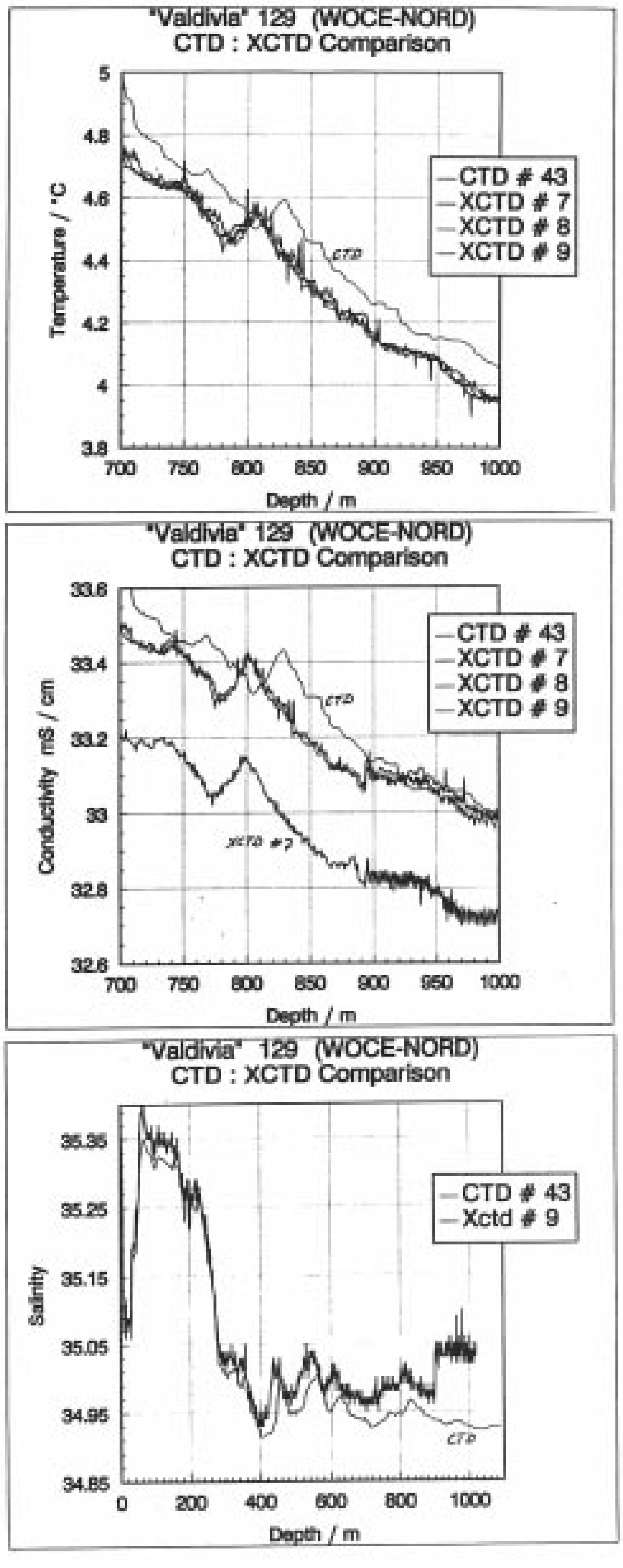

Figure 5: (a) Temperature between 700 m and 1000 m at CTD No. 43. (b) Conductivity between 700 m and 1000 m at CTD No. 43. Note the step and increasing noise at about 890 m. One record (XCTD No. 7) has an offset of -0.3 mS/cm (for the entire profile). (c) Salinity of XCTD No. 9. Note both the increasing depth error and salinity error.

however, the manufacturer should improve the reliability of XCTD measurements. Modified devices are presently being tested at sea by Sippican (J. Hannon, Sippican, pers. comm., 29.3.1993). On the other hand, the scientific community should not shy from taking action, but co-operate in this enterprise.

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ADCP errors in Drake Passage

A most revealing study was done by Gwyn Griffiths (Institute of Oceanographic Sciences Deacon Laboratory, UK) using a new Ashtech 3-D GPS set to calibrate the ship's gyro to 0.14°. He found a heading dependent error which varied from 0 to 1° over 180°. Calibrating out the error made a 25% change to the estimated transport (from ADCP measurements) across Drake Passage.

BATCH TO BATCH VARIATIONS IN IAPSO STANDARD SEAWATER

Several comparisons of different batches of Standard Seawater (Park, 1964; Millero *et al.*, 1977; Poisson *et al.*, 1978; Mantyla, 1980, 1987; Takatsuki *et al.*, 1991) have revealed variability between batches to be far greater than the precision attainable by modern instruments. The general conclusion was that changes took place inside the ampoules after sealing and calibration. The causes of these changes are not understood, but leaching of the glass and microbial activity involving oxidation of dissolved organic material have been suggested.

The greatest discrepancies (0.009 in salinity) were found in 1970 for batches P49-P54 (prepared in the period 1967-1970) and these were attributed to bacterial contamination possibly combined with oil (dissolved) pollution. In most of the older batches (Copenhagen and early Wormley), however, the variations between batches were of the order of ±0.002 in salinity.

Since the introduction of the Practical Salinity Scale (PSS78), in which all batches of Standard Seawater are calibrated in conductivity ratio, K_{15} relative to a defined KCl solution, the batch to batch agreement has improved but the differences are still greater (std. dev. = 0.8×10^{-3} in salinity) than can be attributed to modern instrument precision (0.4×10^{-3}, Mantyla, 1987) or than would be expected in the calibration against KCl solutions. These small changes/differences are most relevant in high accuracy studies of the deep ocean basins and in international global studies such as WOCE.

Ocean Scientific International have introduced a number of practices over the past 2-3 years to overcome some of the problems associated with batch variability. These include:

1. Continuous monitoring of more recent Standard Seawater batches, for changes, against the defined potassium chloride solution.
2. Extended periods of time between bottling and calibration to establish a better equilibration between the seawater and the glass. We are also experimenting with a range of containers and materials.
3. Regular microbial analysis of Standard Seawater during its processing together with appropriate action to discourage microbial contamination or growth. This includes 'point of fill' filtration to 0.1 mm and UV irradiation. The filtration/irradiation regime for Standard Seawater preparation minimises biological growth and dissolved organic carbon.
4. Production of smaller batches to minimise storage time after calibration.

It is important to recognise that we measure shifts in conductivities against the defined potassium chloride (KCl) reference standard, and that comparisons made between batches alone can be misleading. For the purposes of studies such as WOCE, where very small changes in salinity are important, we can provide correction estimates, based on the KCl standard, for more recent batches of Standard Seawater.

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Repeat hydrography line SR1

Ian Vassie has submitted a proposal for peer review for ship time in the period April 1994 to March 1995 (about ten days) to do repeat hydrography on the Drake Passage line. The level of funding for this project will become known in the latter half of 1993.

WOCE INTERLABORATORY CFC COMPARISON

Groups participating in the 1991 CFC Interlaboratory Comparison

Brookhaven National Laboratory	(D.Wallace)
Climate Modelling and Diagnostics Laboratory, NOAA	(J. Butler)
Institut für Meereskunde, Kiel	(M. Rhein)
Laboratoire d'Oceanographie et de Climatologie	(C. Andrie)
Lamont-Doherty Earth Observatory	(W. Smethie)
Pacific Marine Environmental Laboratory	(J. Bullister)
James Rennell Centre for Ocean Circulation	(D. Smythe-Wright)
Scripps Institution of Oceanography	(R. Weiss)
Universität Bremen	(W. Roether)
University of Miami, RSMAS	(R. Fine)

The Chlorofluorocarbon (CFC) Tracer Group at NOAA's Pacific Marine Environmental Laboratory (PMEL) is coordinating the periodic distribution of CFC gas samples to US and international laboratories participating in the WOCE Hydrographic Programme (WHP). This effort should help identify existing calibration differences between participating laboratories and provide a regular check for any long-term drift in their CFC calibration scales. The first CFC Interlaboratory comparison exercise has now been completed.

A set of CFC gas samples for distribution to the participating laboratories was prepared at PMEL by transferring aliquots of clean, dry air from a high pressure cylinder into high-purity secondary cylinders. These primary and secondary cylinders were then analyzed for uniformity of CFC-11 and CFC-12 content, and calibrated relative to CFC standards at PMEL. The secondary cylinders were held for a period of 6 weeks and re-analysed in order to check for drift in CFC content. A secondary cylinder was shipped to each participating laboratory in September 1991.

Most of these laboratories have now completed their analyses of the compressed air samples for CFC-11 and CFC-12 concentrations, returned the cylinders to PMEL for re-analyses, and submitted a final report of their results (see Table for participating laboratories). All participating groups reported results for CFC-11 and CFC-12. Two groups reported results for CFC-113 and one group reported results for carbon tetrachloride.

Within the precision of the analytical techniques used at PMEL, the CFC-11 and CFC-12 concentrations in the cylinders remained uniform throughout the intercomparison exercise. (The CFC-113 and carbon tetrachloride content of the cylinders remained relatively uniform in all but one of the 10 cylinders re-analysed at PMEL).

A final report of the results will be distributed in July 1993 as a NOAA Technical Report, and will be available to all interested parties. This report will include a tabulation of each laboratory's analytical results and a discussion by each group on the methods used to arrive at the reported concentrations.

The range of CFC-11 and CFC-12 concentrations reported by the participating laboratories indicate some differences exist in their CFC calibration scales. When combining WOCE CFC seawater or air data sets reported by different groups, it may be useful in some cases to convert the reported concentrations to a common scale. These conversion factors for CFC-11 and CFC-12 may be obtained from the results given in the CFC Intercomparison Report. If revisions to a group's CFC calibration scales are made in the future, it should also be posssible to report these changes relative to the values provided in the CFC Intercomparison Report. Ultimately, the goal of this programme is to allow the CFC data sets collected by groups participating in the WHP to be merged more easily.

As a follow-up to each intercomparison exercise, recommendations will be made for improving CFC calibration methods, and additional comparisons of primary CFC standards can be arranged on a laboratory-to-laboratory basis.

This CFC intercomparison exercise is scheduled to be repeated at 2 year intervals for the duration of the WHP. Additional compounds (*e.g.*, CFC-113) may be included in future intercomparisons. Research is also underway to determine the feasibility of preparing and distributing stable solutions of dissolved CFCs in seawater as part of the next intercomparison exercise.

CFC groups not participating in the 1991 intercomparison exercise can obtain more information on the 1993 programme by contacting:

John Bullister
NOAA-PMEL
7600 Sand Point Way, NE
Seattle, WA 98115
phone: 206-526-6741
Fax: 206-526-6744
OMNET: J.Bullister
Internet: bullister@noaapmel.gov

OPPORTUNITIES FOR JOINT WORK WITH AUSTRALIA

Australia has ship time available in 1995 or 1996 to do the eastern half of IR2 (8°S, one time I2E) from Sumatra out to about 70-80°E. However, they are in need of someone to do the western half in cooperation with them in order to complete the repeat section.

The one time occupation of I2 is currently scheduled for November-December 1995 so during an opposing monsoon would appear to be the best time to schedule the repeat section. The WOCE Implementation Plan calls for both the one time and repeat sections to be occupied at the extreme of the monsoon, if possible.

Several countries will have ships in the Indian Ocean carrying out WOCE hydrographic surveys after 1994 and which may be in a position to plan a co-operative section with Australia. According to the information held by the WHP Office, Germany will have the Meteor in the Indian Ocean from April-September 1995 and USA JGOFS will have a ship (possibly the Thompson) there for all of 1995, though it is uncertain whether they will be working as far south as 8°S. It is possible NOAA of USA may have a ship in the Indian Ocean during this time period but the WHP Office has no further details. While South Africa is working in the ISS1 area, this is much further south than IR2. The USA will also have a ship (possibly the Melville) in the Indian Ocean from late 1994 to the end of 1995 doing the one time WOCE sections but that ship seems unlikely to be available to help with a repeat section.

If any of you are interested in working with Australia to do this repeat section please contact John Church (Omnet: J.CHURCH, Internet: church@aqueous.ml.csiro.au). Please copy the WHP Office (WHP.OFFICE or whpo@whoi.edu) and the IPO (WOCE.IPO or woceipo@unixa.nerc-wormley.ac.uk) on your reply.

Australia is also still looking for investigators to do tracers (mainly CFCs and He/Tr but others would probably be welcome) on their one time occupations of P12 (S3) in March, 1994 and S4 from 120°E to 160°E during March, 1995. Anyone interested should contact John Church.

THE GLOBAL SUBSURFACE DATA CENTRE, IFREMER, BREST, FRANCE

The data centre located at IFREMER in Brest is, until mid-1993, a purely tropical facility for TOGA; they maintain a continually updated data base of sub-surface thermal data collected since 1985 in all three ocean basins between 30°N and 30°S (referred to as the "global" set). However, as from June 1993 the Centre will be functioning as a truly global data centre, receiving data from all latitudes in all basins. The data set the Centre maintains consists of quality controlled data which have been submitted in delayed mode, plus all data received in real time which have not been replaced by delayed mode submissions.

Techniques for the new data base are being built on the existing TOGA data management system and will be completely compatible with the TOGA set and the existing Global Temperature Salinity Pilot Project (GTSPP). Programming for the new system began in January 1993 and is scheduled to be complete by mid-June. There will be a short period of overlap and by the end of this summer the existing TOGA data management will be abandoned for the new improved system.

New Products from the Upper Ocean Thermal Data Centre

The Centre can now create a very flexible range of products derived either from the "global" tropical set since 1985 or from the monthly real time data sets. At present the products are only available from 30°N to 30°S data, but it is hoped the products will be available from the full WOCE data set in 1994. The data sets are systematically processed to obtain standard derived quantities including temperature at standard depths to 500 m, isotherm depths from 31 to 10°C, heat content down to three standard depths, and thermocline and mixed layer characteristics. Plans are to make these data products available on an operational basis by the end of 1993, either as hard copy, on floppy disks, or by online ftp. Some experimental distributions are being made currently. The format of these data facilitates their processing with standard commercial tools such as spreadsheets or numerical analysis tools.

The Centre has also recently implemented tools to compute climatologies and monthly time series in any given areas in the tropics (30°N to 30°S), including climatological tests against the LEVITUS climatology.

Persons interested in obtaining more information about these products and their availability should contact Jean-Paul Rebert at the address given below.

The WOCE Data Assembly Centre for Surface Temperature and Salinity Data

Underway surface temperature and salinity data are collected on WHP cruises, and by Voluntary Observing Ships using thermosalinographs and buckets. There was no DAC for these data until the Brest data centre offered to perform that role, a decision endorsed by the WOCE SSG.

All WOCE surface salinity data must be submitted to the new DAC. The precise details of submission have yet to be finalised but the WOCE IPO will publicise all the details when they are known. In the meantime the Centre specifies the data will only be accepted if they are sent in a simple ASCII format and are properly calibrated. At this stage the Centre will perform only minimum quality control on the data, and no corrections will be performed. The minimum requirements are set out below:

- The format of the data must be a single standard ASCII file (one observation per line). It is recommended that each cruise constitutes a single file.
- The header to each file must contain the necessary information about the vessel (name and/or call sign), the cruise and the type of instrument used (bucket, thermosalinograph or other). Any other relevant information can be added as text in the file or in a descriptive file.
- Each individual observation must contain the date and time (year, month, day, hour, minute); the position (latitude, longitude in degree, minutes or degree x 100); the salinity (standard scale) and the temperature (recommended but not mandatory).
- The resolution must be 0.1 or higher, and for thermosalinograph the recommended time resolution is one hour.
- Thermosalinograph measurements should have been calibrated prior to the data set shipment. No calibration will be performed by the DAC.
- Data shipments will be accepted on a variety of storage mediums; DOS diskettes, ftp transfer, SUN workstation or Hexabyte cartridges (TAR files) or 1600 bpi magnetic tapes.

At present all the surface observations received for the Atlantic are in a database. A monthly climatology on a 1 x 1° grid has been computed (mean, number of observations, standard deviation) and is used to check the quality of the individual data. Products currently available from the DAC cover only the tropical Atlantic but shortly they will be available for the entire Atlantic, and eventually for the Indian Ocean and then the Pacific Ocean.

The products include the monthly climatology (on PC compatible ASCII files), the PIs data checked and returned with the standardised anomalies of individual observations, maps of observations locations and statistics (but no contouring) and a gridded monthly climatology resulting from an objective analysis. On an annual basis, hard copy or analysis results will be available of the time-space evolution of surface salinities and anomalies along major ship lines providing *ad hoc* sampling.

No restrictions on the availability of the data are planned, except if a PI requires initial confidentiality of a specific dataset. Selected regional data subsets are available on request, and all sets distributed will have the originator clearly identified.

For further information please contact Alain Dessier at the address below.

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Drake Passage: Instruments at new locations

In late October/early November 1992 Ian Vassie (Proudman Oceanographic Laboratory, UK) recovered moorings (Bottom Pressure Recorders plus Inverted Echo Sounders) from the old positions. Two new moorings (each with BPR plus IES) were deployed on the agreed positions on the ERS-1 line on the 1,000 m contours at each end of Drake Passage (see WOCE Newsletter No. 13, p. 13). The southern mooring was deployed on 4 November 1992, the northern one on 13 November. A trial BPR system was deployed on the ERS-1 line in deep water 60 nm north of the southern mooring. The system has pop-up modules to return the data, one of which was successfully recovered with data three weeks after deployment. The three moorings will be left in place for at least a year, and it is the intention to continue them.

NEWS FROM THE WOCE SEA LEVEL DAC OPERATED BY BODC

The international WOCE programme is establishing two sea level Data Assembly Centres (DACs), responsibility for which has been vested jointly in the University of Hawaii and the British Oceanographic Data Centre (BODC).

The 'delayed mode' DAC at BODC began its activities early in 1991. It is responsible for the assembly, distribution and supply of sea level data to the full extent of quality control possible covering all of the 100 or so gauges in the WOCE network. The DAC is corresponding with about 25 data suppliers, who have been requested to supply historical data in addition to recently collected data. The TOGA Sea Level Center at the University of Hawaii have supplied copies of the data collated by them. Close links are maintained with the University of Hawaii which will operate the 'fast' sea level DAC for WOCE.

Approximately 95 of the stations are operational and data have been received from 60 of these. Data have been supplied to the DAC by Argentina, Australia, Chile, Cuba, Denmark, Ecuador, France, Iceland, Japan, New Zealand, Peru, Philippines, Portugal, Russia, the UK and the USA. Since the DAC began its activities gauges have been installed at Ammassalik (Greenland), St. Peter and St. Paul Rocks (Brazil), Porto Grande (Cape Verde), Diego Ramirez (Chile), Amsterdam Island (France), Kerguelen Island (France), Dakar (Senegal) and South Caicos (UK). The total volume of data received so far by the DAC is about 850 site years. A few sites have data extending back over 50 years and many have data extending back over 20 years.

Data quality control is carried out with the aid of high speed graphics workstations and sophisticated screening software, which allows rapid visual inspection of the data. The software is designed to deal with many parameters so predictions and residuals can be viewed simultaneously with the sea level data. Any other parameters, for example atmospheric pressure, can also be displayed. The quality control identifies spikes and gaps in the data, in addition to timing problems and datum shifts. Any problems identified can then be resolved with the data supplier. Qualifying information accompanying the data is also checked and data documentation assembled.

A data tracking system has been established to ensure that up to date information pertaining to the WOCE gauges is readily available. This includes general information about each tide gauge site in addition to information about what data are held by the DAC and whether they have passed through the quality control procedures. Regular summaries of the data available, extracted from the tracking system, are produced. Close collaboration is maintained between the sea level scientists at POL, BODC and the PSMSL. It is intended that distribution of the data to the scientific community should be possible within 18 months after data collection. BODC will also ensure archival of the sea level data as a WOCE data set in the World Data Centre system.

The DAC has recently set up a public access directory containing the WOCE Sea Level Catalogue to allow access over Internet, and over the next 6 to 9 months we hope to make the data available over Internet as well. Instructions for access to the directory are given in the panel below.

WOCE Sea Level DAC Data Catalogue Public Access Directory

This directory contains a copy of the WOCE 'delayed-mode' Sea Level DAC Data Catalogue. It was introduced in February 1993 and at present has experimental status.

To access the files, connect by Anonymous FTP to a Silicon Graphics workstation at Bidston called bisag.nbi.ac.uk or Internet Number 192.171.134.7

In response to 'Name' enter 'anonymous' or 'ftp'.

In response to 'Password' enter your own home userid@address.

Then type 'cd pub/bodc/wocesl' to connect with this directory and transfer files to your home directory with 'get'. If there are any problems, or if you have any comments, please contact us either by e-mail at BODC.UK (Omnet) or ljr@ua.nbi.ac.uk (Internet) or one of the telephone, fax or telex numbers below.

The WOCE Sea Level DAC files you will find in the public directory are as follows:

WOCESL.README	-	this information
WOCEDAC.inf	-	latest available report of the DAC activities
WOCESL.cat	-	catalogue of WOCE Sea Level DAC data holdings

Later on we hope to include data files (containing hourly values of sea level) for WOCE Sea Level sites in the public access directory. In the meantime, to obtain any data please contact either Lesley Rickards or Sally Dowell by e-mail, fax, telex, telephone or mail (at the address given below).

WOCE Sea Level DAC,
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Tel: +44 51 653 8633
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Telex: 628591 OCEANB G

WOCE CALENDAR

Sixth WOCE Core Project 1 Working Group Meeting (CP1-6)
30 August - 1 September 1993, Kiel, Germany
Contact: F.SCHOTT/J.TOOLE/WOCE.IPO

Seventh WOCE Executive Meeting (EXEC-7)
2 - 3 September 1993, Wormley, UK
Contact: WOCE.IPO

Twelfth WOCE Hydrographic Programme Planning Committee Meeting (WHP-12)
8 - 10 September 1993, Woods Hole, MA, USA
Contact: J.SWIFT/WOCE.IPO

Eighth WOCE Numerical Experimentation Group Meeting (NEG-8)
and Large Scale Ocean Models Workshop
13 - 15 September 1993, Patricia Bay, BC, Canada
(to be followed by Joint NEG/SGCCM Meeting 16 - 19 September)
Contact: IOS.WORMLEY/WOCE.IPO

TOGA/WOCE XBT/XCTD Programme Evaluation Workshop (TWXPEW)
13 - 16 September 1993, Brest, France
Contact: INTL.TOGA/ORSTOM.BREST/WOCE.IPO

Sixth WOCE/TOGA Surface Velocity Programme Planning Committee Meeting (SVP-6)
28 - 30 September 1993, Honolulu, HI, USA
Contact: P.NIILER/WOCE.IPO

WOCE Western Pacific Coordination Workshop
Autumn 1993, Honolulu, HI, USA
Contact: WOCE.IPO

WOCE North Atlantic Hydrographic Workshop
Autumn 1993, Hamburg, Germany
Contact: WOCE.IPO

Twentieth WOCE Scientific Steering Group Meeting (WOCE-20)
9-11 November 1993, Tokyo, Japan
Contact: N.SUGINOHARA/WOCE.IPO

Sixth WOCE Data Management Committee Meeting (DMC-6)
1 - 2 December 1993, Boulder, CO, USA
Contact: WOCE.IPO

WOCE/TOGA-COARE/JGOFS-EQ.PAC Pacific Meeting
July 1994, Hawaii, USA
Contact: WOCE.IPO

Symposium: “The South Atlantic: Present and Past Circulation”
15-19 August 1994, Bremen, Germany
Contact: G.SIEDLER, WOCE.IPO

Twenty-first WOCE Scientific Steering Group Meeting (WOCE-21)
September 1994, Kiel, Germany
Contact: WOCE.IPO

Third Session of the Intergovernmental WOCE Panel
October 1994, Paris, France
Contact: A.ALEXIOU, WOCE.IPO

WORLD CLIMATE RESEARCH PROGRAMME

WOCE is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of WOCE is under the guidance of the JSC Scientific Steering Group for WOCE, assisted by the WOCE International Project Office. JSC is the main body of WMO-ICSU-IOC, formulating overall WCRP scientific concepts.

The WOCE Newsletter is edited at the WOCE IPO at IOSDL, Wormley, Godalming, Surrey, UK. Financial support is provided by the Natural Environment Research Council, UK.

Scientific material should not be used without agreement of the author.

We hope that colleagues will see this Newsletter as a means of reporting work in progress related to the Goals of WOCE as described in the Scientific Plan. The SSG will use it also to report progress of working groups, experiment design and models.

The editor will be pleased to send copies of the Newsletter to institutes and research scientists with an interest in WOCE or related research.